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TECOM PROJECT NO. 8-WE-900-139-016
REPORT NO. USACSTA-6569

US ARMY MATERIEL COMMAND

RESEARCH REPORT

OF

MINE DETONATION DETECTION SYSTEM (MDDS)

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K.A. DORSEY
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DEVELOPMENT AND ANALYSIS

U.S. ARMY COMBAT SYSTEMS TEST ACTIVITY
ABERDEEN PROVING GROUND, MD 21005-5059

SEPTEMBER 1987

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005 – 5055

REPLY TO
ATTENTION OF

10 MAY 1988

AMSTE-TE-T (70-10p)

MEMORANDUM FOR: Commander, U.S. Army Combat Systems Test Activity, ATTN: STECS-DA-I

SUBJECT: Research Report of Mine Detonation Detection System (MDDS), TECOM Project No. 8-WE-900-139-016

Subject document has been approved by this headquarters and is provided for information (enclosure 1).

FOR THE COMMANDER:

For: D. G. Patterson, LTC
MICHAEL C. RITONDO
Acting Chief, Troop Support Division
Directorate for Test

Encl

CF:
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19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Instrumentation support requirements for the Developmental Test II (DT II) of the Volcano System prompted the development of the Mine Detonation Detection System (MDDS) to acquire mine self-destruct times. Mine self-destruct time is an important mine reliability parameter. The development of the MDDS started in August 1986 and continued until March 1987. Tests utilizing the system began in April 1987. The mines used for this test (Type 20) have a small explosive charge and do not come apart when detonated. After detonation there is no physical indication that the mine has detonated. The MDDS detects the vibrations generated when the mine goes off, time tags that event, prints the time, and then stores it. The MDDS does this for up to 200 deployed mines, normally with an area that has a major diameter of 900 feet. A larger area is possible with cable extension equipment. JTS)

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FOREWORD

The U.S. Army Combat Systems Test Activity (USACSTA), Aberdeen Proving Ground (APG), MD, was responsible for the design of the Mine Detonation Detection System (MDDS), its software, the overall data acquisition scheme, and the methodology developed employing these elements. Fredrick Manufacturing Co., of Fredrick, MD, built the MDDS.

SECTION 1. SUMMARY

1.1 BACKGROUND

The self-destruct time of the mines dispensed by the Multiple Delivery Mine System (Volcano) is an important mine reliability parameter that required the development of a new Mine Detonation Detection System (MDDS) in order to collect these data.

The MDDS fulfills the requirement to automatically monitor and detect the detonation of up to 200 mines. Before designing the MDDS, previously developed detonation detection systems were looked at for ideas.

Mine detonation detection systems at Aberdeen Proving Ground from the 1950's to the 1970's, used microphones and infrared detectors as sensors. One very successful device developed in the 1960's could distinguish the detonation of a down loaded mine against the background noise of a tank. The system used an in-house designed microphone that contained a diaphragm, piezoelectric crystal and transistor to sense the detonation. The microphone was tuned to the frequency of the audio signal emitted by the mine when the prime fuze functioned. The output of the microphone was fed into signal conditioning circuitry and them to a comparator that controlled the gate of a Silicone Controlled Rectifier (SCR). When the SCR conducted, the capacitor in series with it, would discharge and activate the solenoid on a speed graphic camera. This system monitored one mine.

Other systems during this period used microphones and strip chart recorders. The microphones monitored one mine or several mines. The output of the microphones were fed into chart recorders. When monitoring individual mines, one chart recorder channel per mine was required. Infrared detectors were used with fully loaded mines. The infrared detector would generate a pulse when it sensed the infrared signature of an exploding mine. The pulse was amplified and displayed by a chart recorder. The occurrence of a detonation would be known but not the identity of that mine.

The above systems and several variations were successfully developed and used by the Special Ordnance and Small Arms Development Laboratory, U.S.Army Combat Systems, Test Activity (USACSTA). These techniques were used primarily during the 1950s through the 1970s.

During the early 1980s, the Instrumentation Development Branch (IDB) USACSTA, developed a microprocessor based detonation detector that could monitor 64 mines. The Mine Event Logger System (MELS),as it was called, was designed to check the conductivity of a thin wire placed over each mine. When a mine detonated it broke the wire. The MELS Microprocessor Control Unit (MCU) checked the conductivity of all of the mine wires once every minute and recorded the time that they were broken. The system worked well.

During 1985 a detonation detector was introduced that was physically coupled with the mine and produced a light flash when detonated. The sensor was a Lucky Fuze, which is a piezoelectric crystal originally used in the nose of a 90-mm projectile with a point initiating, base detonation fuze. When the mine detonated (down loaded mine), the crystal generated a voltage that was applied to the gate of a SCR. The SCR would conduct and set off a flash bulb that was in series with the SCR and a 9-volt battery. Each mine was instrumented with the detector discribed above. An observer seeing the flash would note the time of detonation.

With the knowledge of detonation detectors used over the past three and a half decades as a base, the system described in this report was developed to provide accurate and reliable mine detonation detection.

1.2 OBJECTIVES

The objectives are to:

a. Developed a system that will automatically monitor and detect the detonation of up to 200 mines. The design goals of this system include:

(1) Centralized Monitoring and Control.

(2) Automatic data collection.

(3) Uninterruptible power supply.

(4) High reliability.

(5) Hardware and software flexibility.

b. Provide a detailed description of the MDDS.

c. Provide an operational description of the MDDS.

1.3 SUMMARY OF PROCEDURES

The procedures developed for mine detonation detection of down loaded mines (Type 20) are:

a. Survey a map of the intended mine field pattern to determine if all the mines can be instrumented.

b. Decide on a location for the monitoring equipment. This equipment has to be enclosed and provided with a voltage source of 110 VAC. Provisions have to be made for routing a maximum of ten 1/4-inch diameter cables.

c. Dispense mines.

d. Emplace the remote boxes in mine field, connect multiconductor cable and run to interconnect box (part of monitoring equipment).

e. Run 20 sensor wires per remote box to the test mines. Cement sensors to mine surface using dental cement.

f. Initialize the monitoring system.

1.4 SUMMARY OF RESULTS

The MDDS (fig. 1.4-1), worked as designed. It provided accurate and reliable mine detonation detection data on Type 20 mines (limited usability during future tests) during the DT II of Volcano.

Instrumenting the mine field was not a difficult task because the mines could be easily seen, the dispersion made it easy to walk through the field, and anti-personnel mines were not used (not a normal mine field configuration). During setup, stakes were hammered in near each mine for sensor cable strain relief (fig. 1.4-2). When instrumenting the mine field, no premature detonations were noted that were linked to the attachment of a sensor. The premature detonations that happened during the instrumentation of the mine field were caused by people accidentally moving the mines or bringing metal objects too close.

The portion of the system that is in the mine field can withstand the wind and rain; however, electrical noise can present a problem. When a Type 20 mine detonates, the mine sensor generates 2 to 4 volts. The remote box threshold voltage is set at 1.5 V. Whenever a voltage spike from the sensor exceeds the 1.5 V reference, a mine detonation indication is given. Electrical noise in the atmosphere can cause spikes on the line that give false detonation indication. The longer the sensor cable the more noise induced. The normal noise level on a sensor cable fully extended is about 80 mV, far below the 1500 mV needed to reach the threshold. However, when the atmosphere is especially noisy, spikes of 500 to 1000 mV can occur. Occasionally a larger spike will be induced on the line. A solution to immunize the MDDS against these rare occurrences exists and is discussed in paragraph 1.7.

The remote unit drivers can reliably drive three sections of cable between the remote box and the interconnect box. The remote box sits in the mine field with 20 sensor lines connected to it. The status of these lines are sent back to the Vehicle Performance Recorder (VPR) via a multiconductor cable called a remote interconnect cable. The VPR is a self-contained data acquisition system and is described in paragraph 2.1. Each cable is 350 feet in length. The cables can be connected together via a cable extender box which provides a straight-through connection for each conductor. The remote box drivers can drive three cable sections with a total length of 1050 feet. At present, only two extender boxes exist. The need for additional extender boxes is expressed in paragraph 1.7.

1.4 (Cont'd)

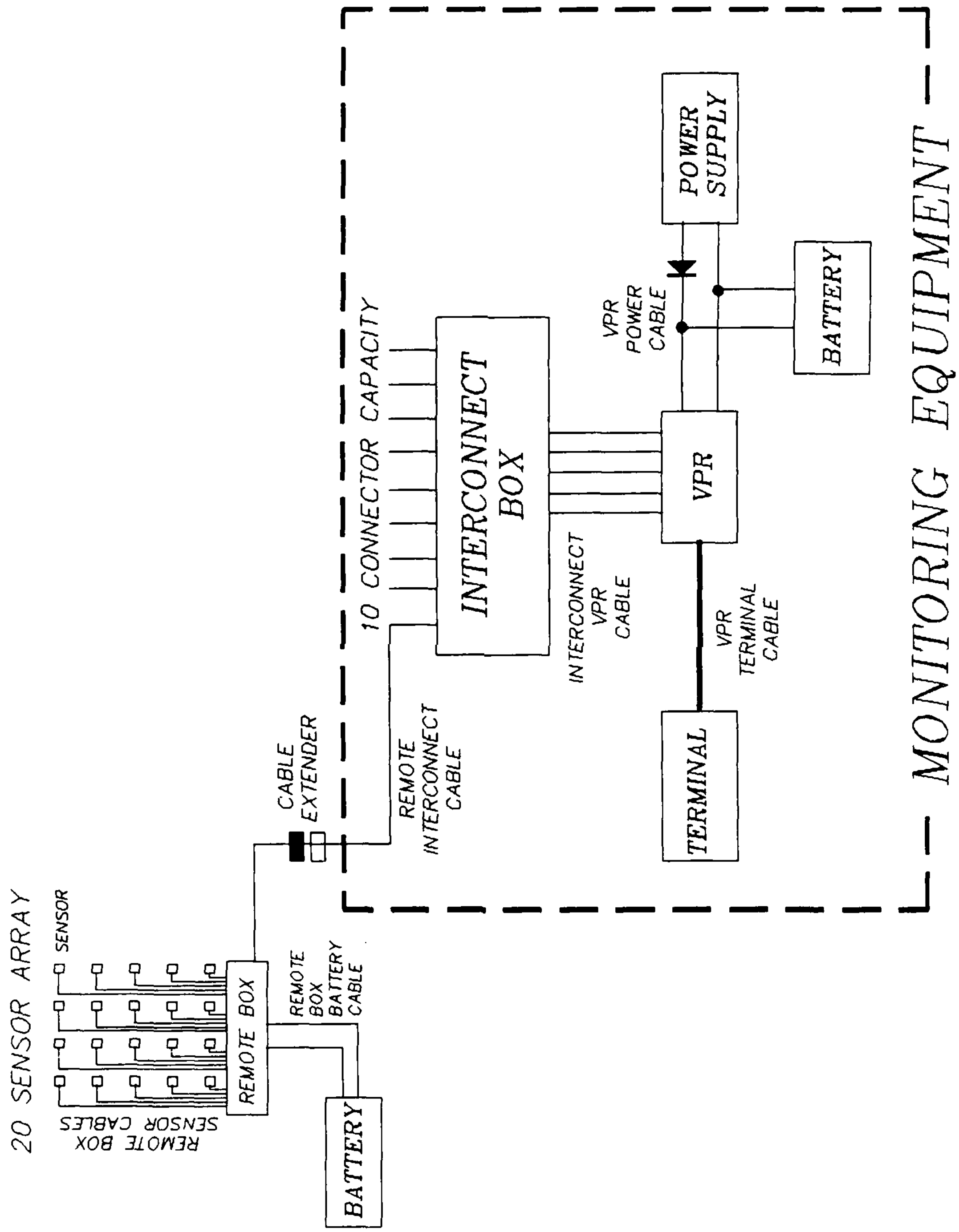

Figure 1.4-1. Mine Detonation Detection System (MDDS).

1.4 (Cont'd)

Figure 1.4-2. Instrumented mine.

1.5 ANALYSIS

The MDDS successfully detected Type 20 Volcano mine detonations during the DT II of those items.

The absence of antipersonnel mines made the instrumentation of the field easier and safer. When at all possible, antipersonnel mines should be avoided when trying to collect time-out data. Late armings could cause injuries to surveyors and instrumentation personnel. Having to avoid trip lines will delay the instrumentation of the mine field and possibly increase the number of premature detonations caused by test personnel.

Electrical noise induction is a potential problem with the sensor cable only. The conductors in the remote interconnect cables are normally high and go low when the corresponding mine detonates. The steady-state noise level is a good parameter to monitor when trying a different mine field area. To collect data on this parameter, fully extend a sensor cable into the mine field and connect the terminal end to an osciloscope. Observe the steady-state close up noise level. Samples of voltage spikes can be collected by using a storage scope instead of a regular one. Set the scope to trigger off of the spikes. The remote box threshold level should be set above the highest spike recorded and below the minimum output of the sensor.

Having additional cable extender boxes available gives the tester the option of increasing the diameter of the area that can be instrumented. Without cable extenders the major diameter of the coverage area is 900 feet. With six cable extenders, diameter increases to 1600 feet; however, with the 12 cables available only 120 mines could be monitored. In a practical mine field, mines nearby would not require the extender so you have various length of cable.

1.6 CONCLUSIONS

The data acquisition system described in this report provides a valuable tool for evaluation of mine self-destruct time, an important mine reliability parameter. Equally as important as the system is the supporting documentation contained in this report. The documentation will insure that future refinements of this system or other developments to our detonation detection capability, will have as their base the efforts for this system's development.

1.7 RECOMMENDATIONS

It is recommended that:

a. Four additional cable extenders be procured, bringing the total to six.

b. Sensors be procured that have a higher voltage output than the LAW nose cones per corresponding g level. The light antitank weapon (LAW) nose cones are adequate for monitoring the Type 20 mines; however, the newly available sensors will provide more flexibility for monitoring other events that are not as violent as the Type 20 mine detonation. The signal can also be attenuated for events more violent than the Type 20 detonation. The higher output would also increase the system's immunity to noise because the threshold could be raised. The output of the LAW nose cone during a Type 20 detonation is from 2 to 4 V. The output of the new sensor during the same detonation is 2 to 3 times higher. The LAW nose cones are described in detail in paragraph 2.3.1.

c. The remote boxes be modified by adding resistors across the inputs in a dual-in line package (DIP)(fig.1.7-1). This package would allow for easy variance of the input resistance because you can readily change resistor integrated circuits (ICs). Changing the resistance varies the attenuation of the input signal and noise level.

d. An additional VPR be requested for support of mine testing. An additional VPR would allow the option to use both to monitor the same mine field (fig.1.7-2). An advantage to this would be an increase in the mine field area that could be covered. An additional terminal would be required but any terminal that has an RS-232 interface would be sufficient. Additional parallel input/output (I/O) cards would also be needed. This concept could be applied to monitoring different mine fields simultaneously. The VPRs are USASCTA test instrumentation resources that are allocated according to test item priority and other consideration.

e. A weatherproof housing be constructed for the remote unit. The present housing provides limited protection and has to be covered when set up in the mine field.

f. The system should have a check-out mode to insure that instrumentation is functioning from the mine to the recorder. It should also have a false alarm algorithm to detect false alarms, record them, and relatch the affect remote control box/mine sensor(s).

1.7 (Cont'd)

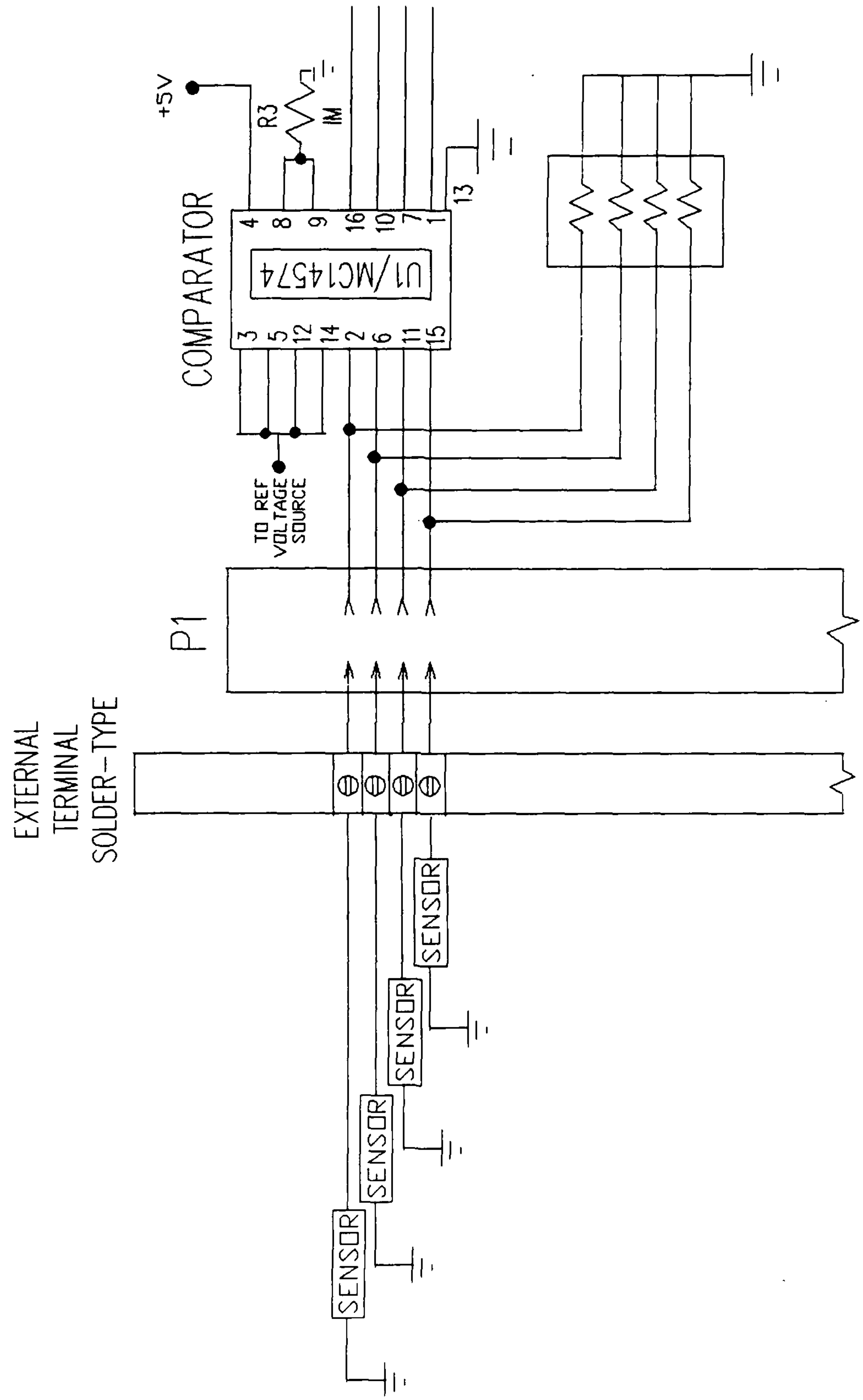

Figure 1.7-1. Modified remote box.

1.7 (Cont'd)

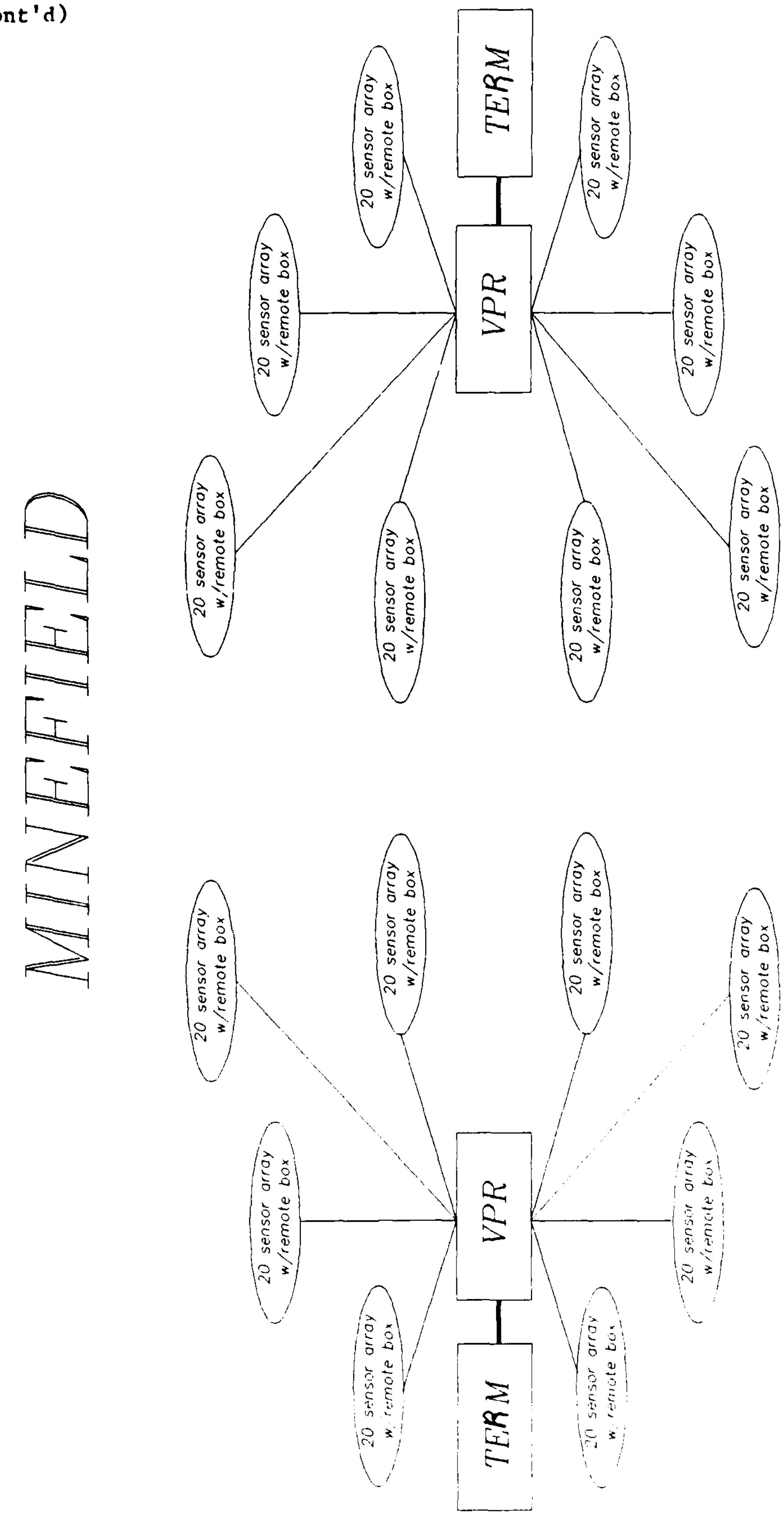

Figure 1.7-2. Two vehicle performance recorder options.

SECTION 2. DETAILS OF INVESTIGATION

2. SYSTEM TECHNICAL DESCRIPTION

The MDDS continually monitors the status of up to 200 mines and reports the date and time of each mine detonation. Descriptions of how this is accomplished is presented at different levels of detail within this section.

When a mine detonates, the remote box senses this occurrence via a sensor and sensor cable. A multiconductor cable that stretches from the remote box to the VPR (via the interconnect box) carries that information. The voltage on the corresponding conductor, that represents the mine, goes low. This line is terminated at one of the parallel I/O card input in the VPR. The VPR's I/O processor continually runs a task that monitors these cards. The I/O processor collects the status of all these inputs (200) every 20 ms and stores them in banked memory.

The VPR's data processor accesses the status of these inputs and tests to find out if there have been detonations since the last check. If there has been, the data processor will time-tag the mine number with the time of day and date. This information is sent to the display and printer. It is also stored for easy retrieval using various data formats.

2.1 VEHICLE PERFORMANCE RECORDER (VPR)

The VPR is a small, self-contained multiprocessor based data acquisition and processing system (fig. 2.1-1). It was designed to be installed on a vehicle to acquire, process, and store data, and is easily adaptable to other harsh environment applications. The power of the system and its inherent flexibility made it ideally suited for monitoring the status of up to 200 mines. The VPR measures 33.0 by 25.4 by 22.8 cm (13 by 10 by 9 in.), weighs approximately 16.8 kg (37 lb), and requires 1.8 amps at 28 VDC for operation. The VPR operates over a temperature range of -40 °C to 85 °C.

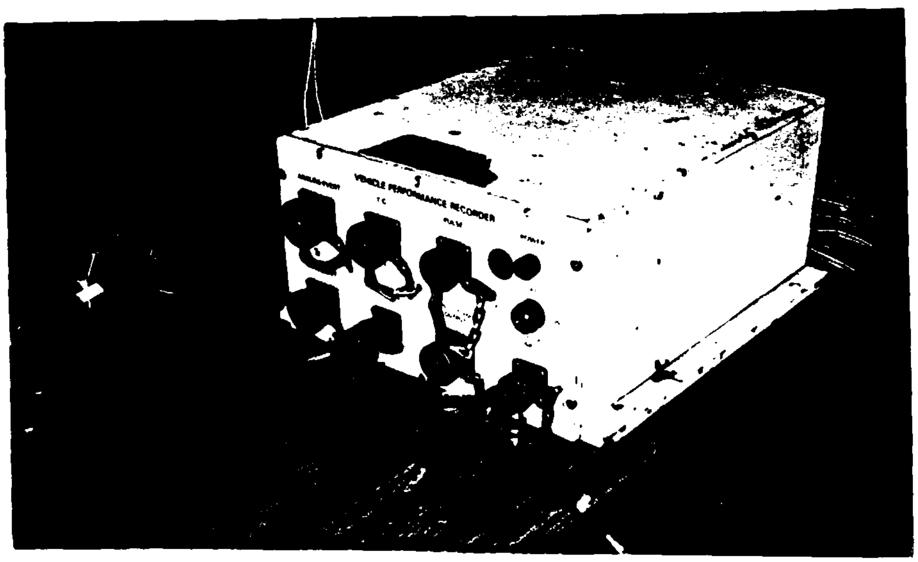

Figure 2.1-1. Vehicle performance recorder.

2.1.1 VPR Hardware

Figure 2.1-2 is a block diagram of the VPR hardware, consisting of a Transterm 3 portable terminal with printout capabilities, and printed circuit assemblies (seven commercially available and two developed in-house) installed in a ruggedized housing. The printed ciruit assemblies provide the following:

a. An 8-bit CMOS microcomputer dedicated to data processing (fig. 2.1-3).

b. An 8-bit CMOS microcomputer dedicated to I/O (fig. 2.1-4).

c. Dual serial I/O (for terminal control) (fig. 2.1-5).

d. 64K additional RAM (fig. 2.1-6).

e. Parallel I/O (five boards) (fig. 2.1-7).

The primary purpose of the I/O board with 16K ROM and 8K RAM is to monitor mine detonation via the parallel I/O boards. When a signal indicating a mine detonation comes from the remote boxes it enters the parallel I/O board. A mine detonation is indicated by a logic low on the parallel I/O board. These data are stored in bank memory (64K RAM); from which the data processing board can get this information. The I/O board continuously monitors the parallel I/O boards via Cim-bus, which is the N.S.C. interface bus. Every 20 ms the Central Processing Unit (CPU) receives a signal from the interrupt controller to update the information in bank memory.

The primary purpose of the data processing board is to give the data received from bank memory a detonation time and display detonation information on the terminal. The CPU controls the interrupt controller and communicates with the I/O CPU via the hardware mailbox. The current date and time are entered by the operator, and is used to establish the actual detonation time. The data processor also controls the dual serial I/O board.

The five parallel I/O cards in the VPR play an important role in the hardware of the MDDS. Each card is capable of receiving 40 inputs from the remote boxes. These cards along with the software resident in the I/O board gives the system a 200 mine capability. Two parallel I/O port chips are used on the parallel I/O board which are programmed to be used solely as inputs. Figure 2.1-8 shows the block diagram of the board. There are several jumper positions on the boards. Each is used to provide a specific function, whether the jumper position is connected or not. Also each board is individually addressed using its unique jumpered address. Each card uses eight addresses to access such functions as input, output, and status. The address assignment is provided in Table 2.1-1. The five base addresses are 80H, 88H, 90H, 98H, and A0H. Figure 2.1-9 shows the jumper position layout.

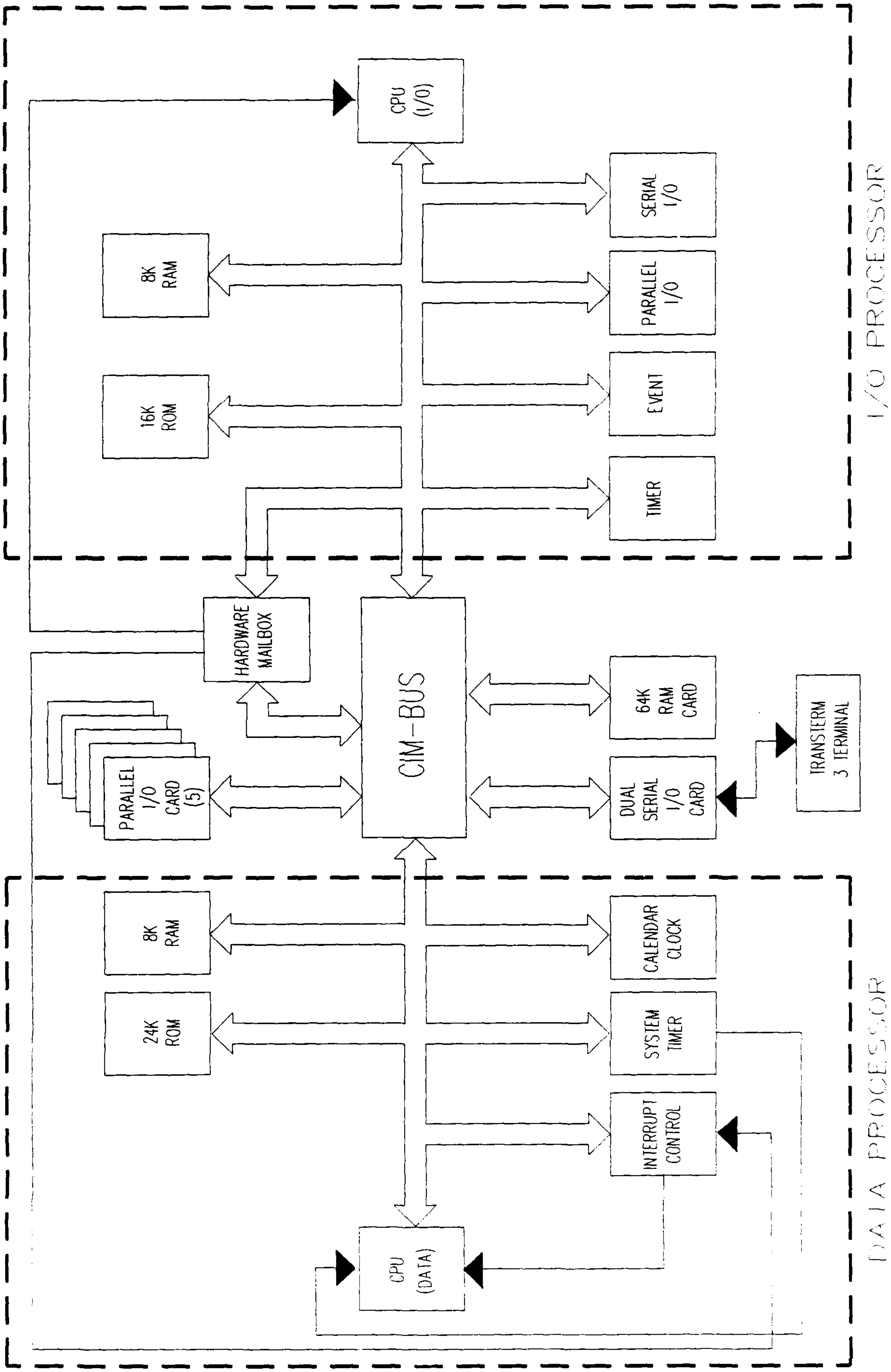

Figure 2.1-2. VPR hardware functional block diagram.

2.1.1 (Cont'd)

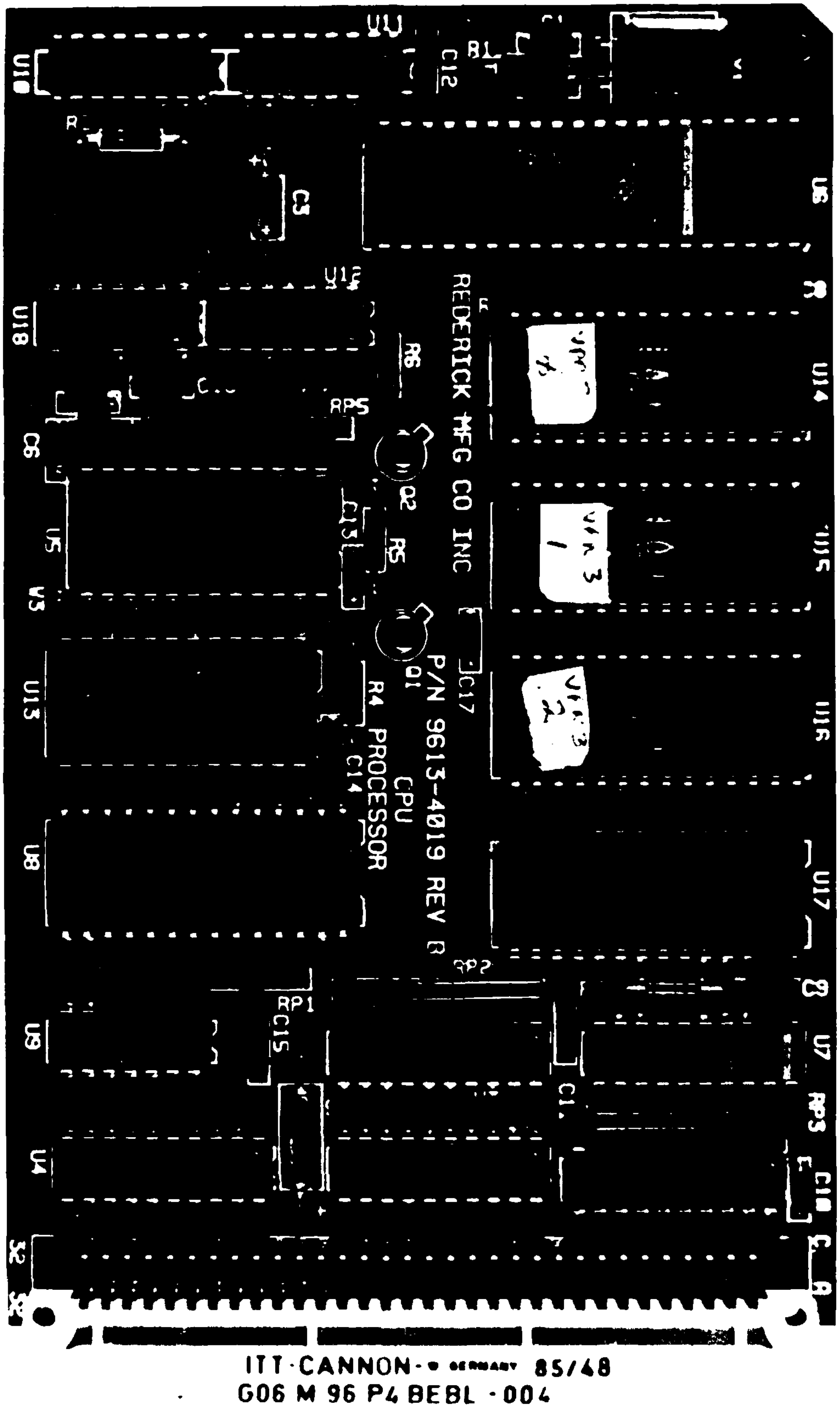

Figure 2.1-3. Data processor.

2.1.1 (Cont'd)

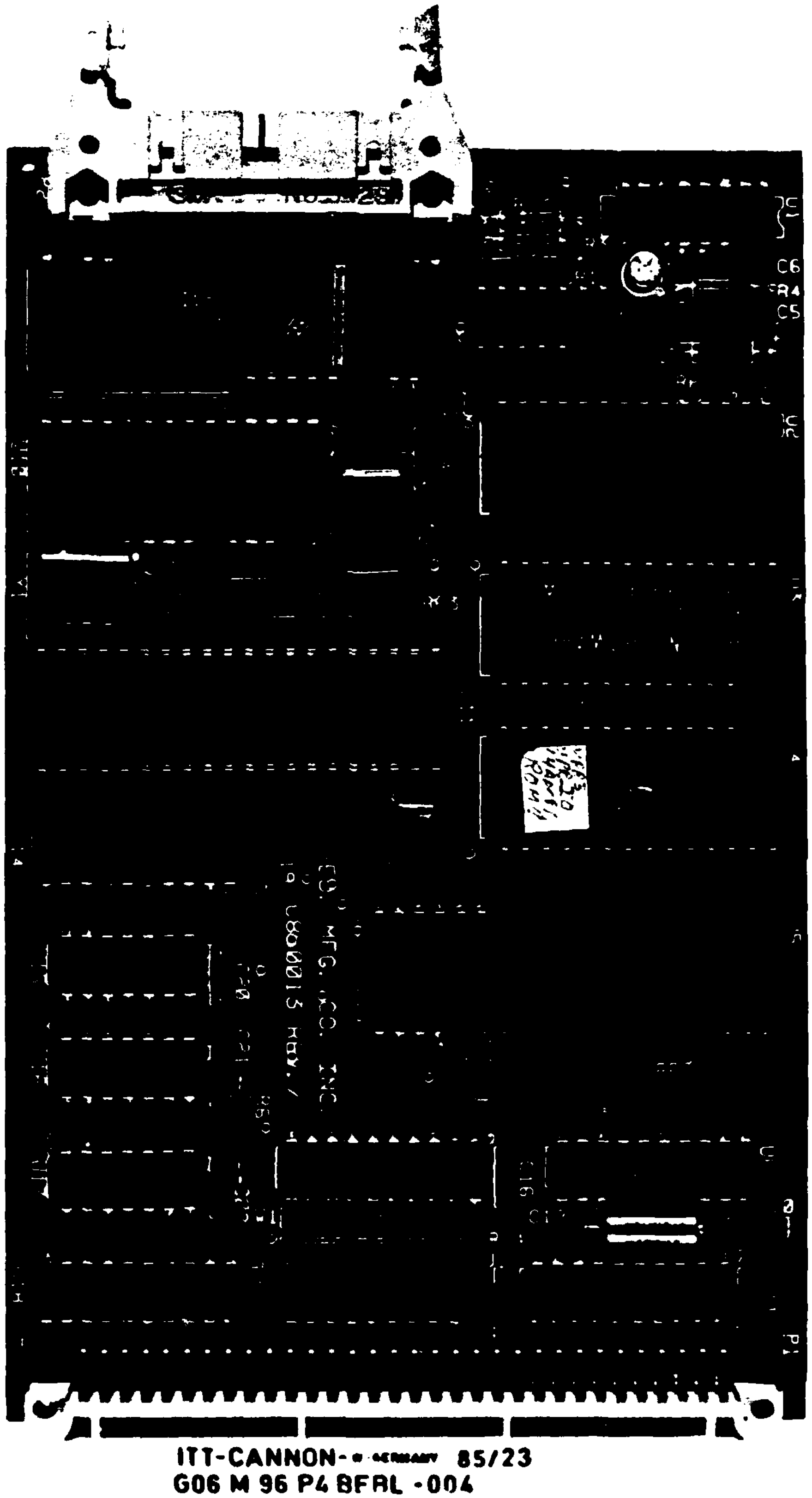

Figure 2.1-4. I/O processor.

2.1.1 (Cont'd)

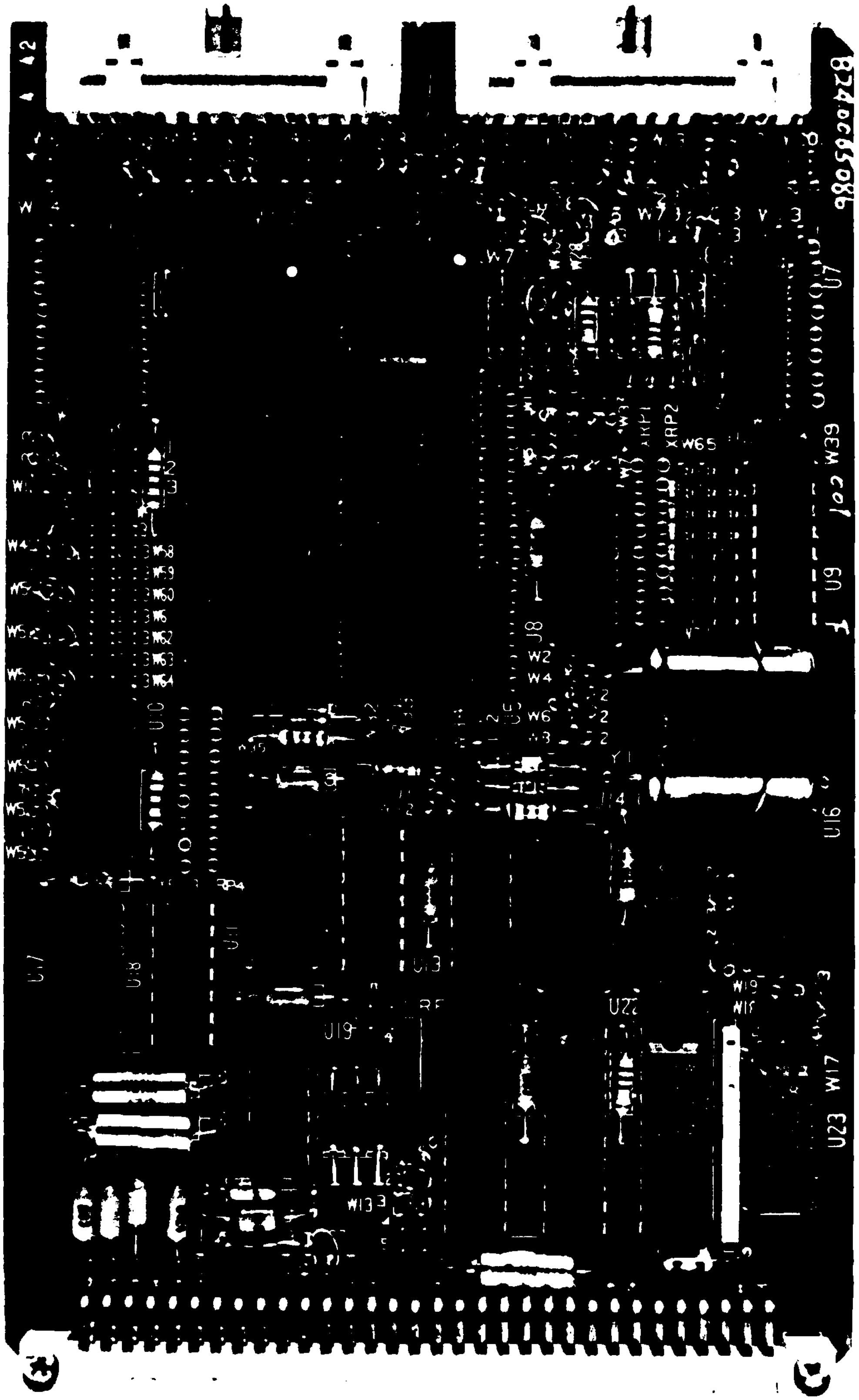

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Figure 2.1-5. Dual serial I/O.

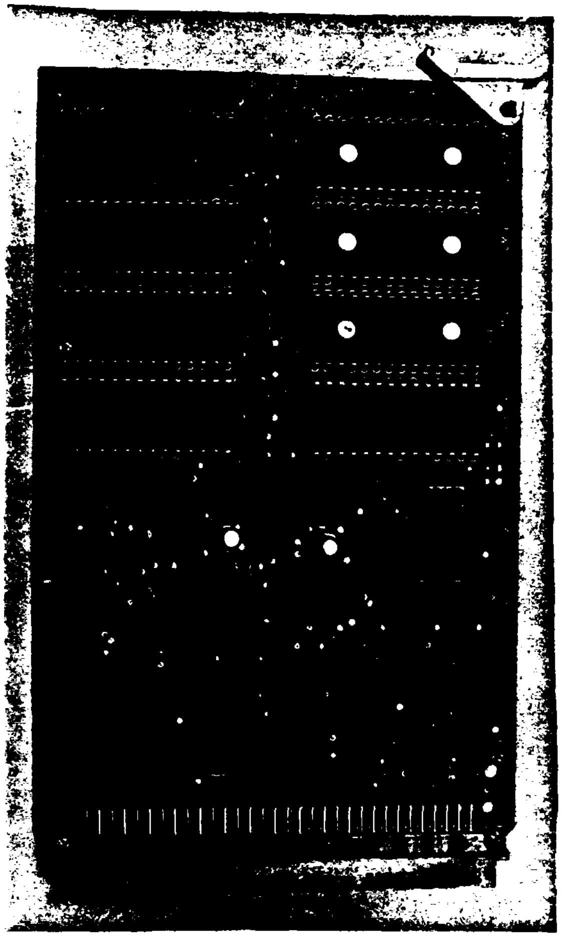


Figure 2.1-6. Bank memory.

2.1.1 (Cont'd)

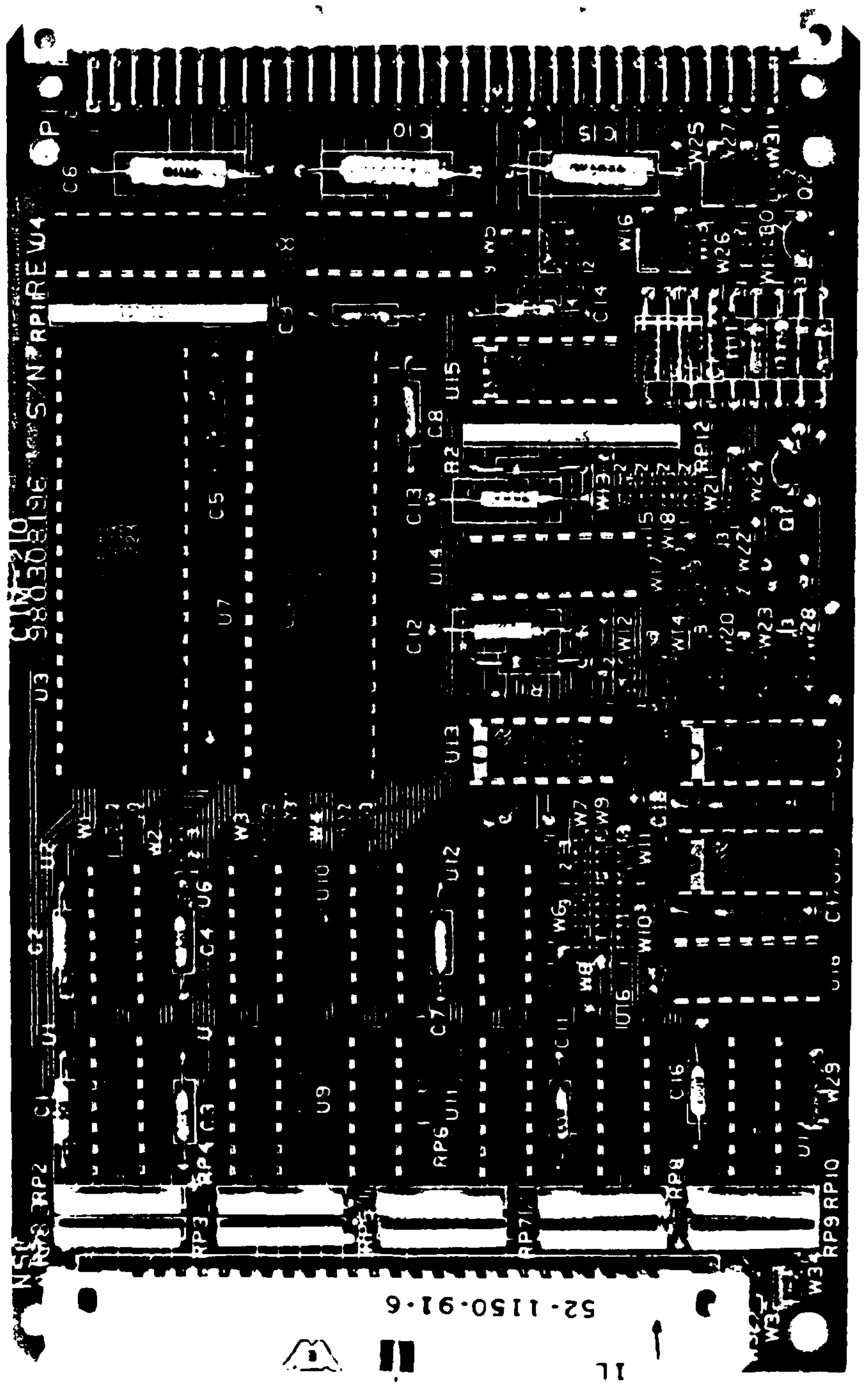


Figure 2.1-7. Parallel I/O.

2.1.1 (Cont'd)

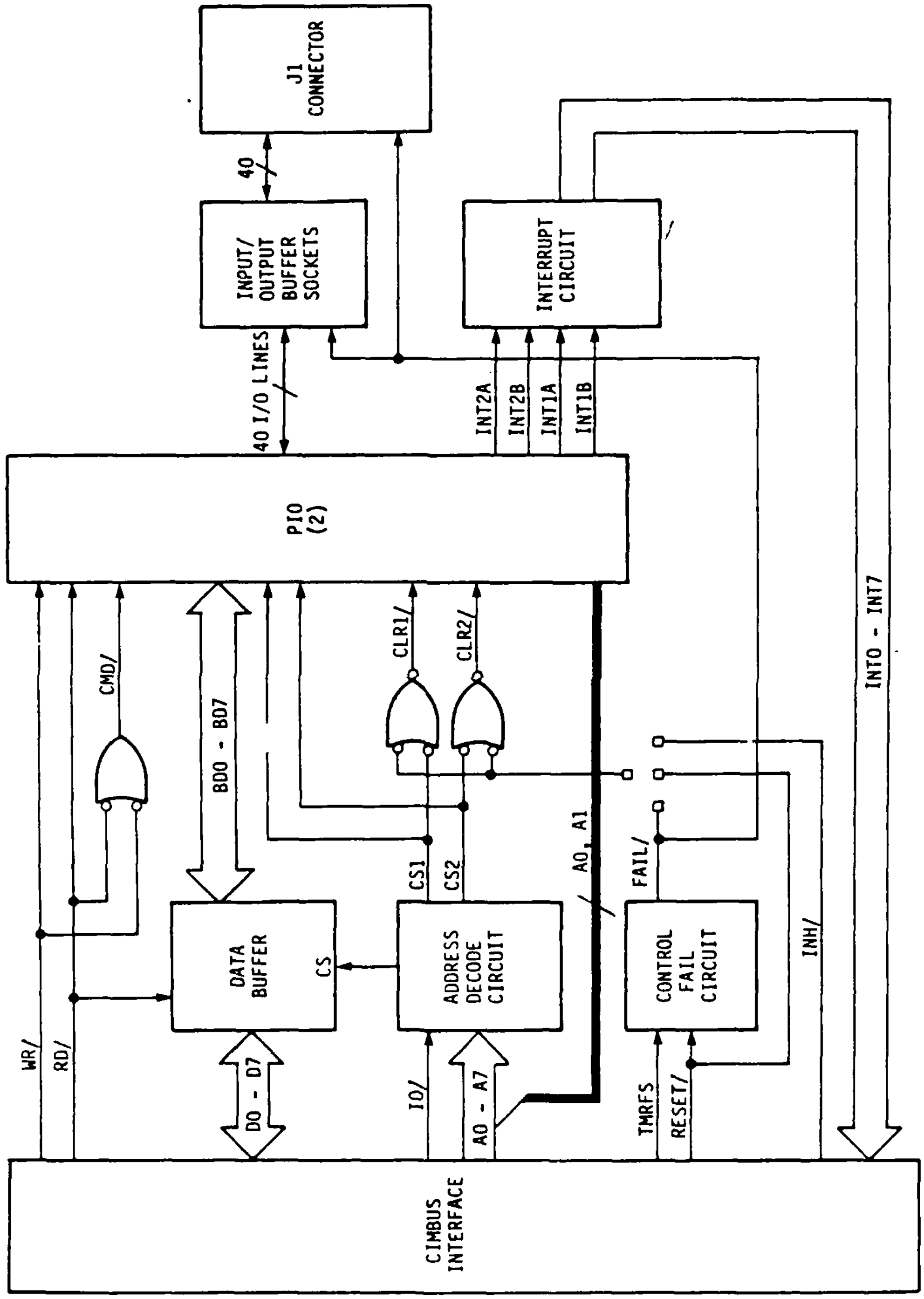
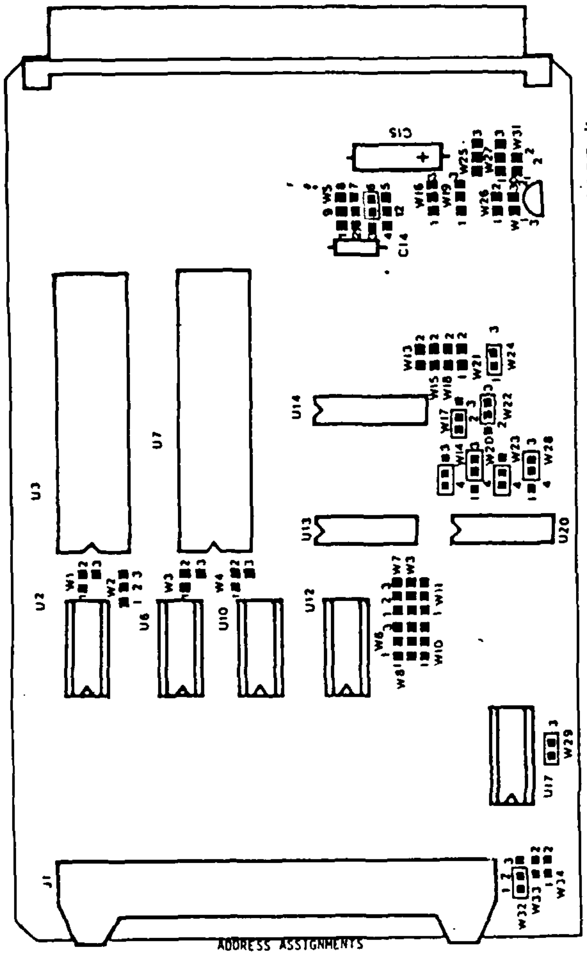


Figure 2.1-8. Parallel I/O board, functional block diagram.

2.1.1 (Cont'd)



JUMPER CONFIGURATION

CIM-210/-210C

JUMPER NO.	STATE	FIELD AREA	FUNCTION
W1-1 to W1-2	Open *	1	When closed, connects +5 VDC S pullup to U1.
W1-2 to W1-3	Open	1	When closed, connects +15 VDC E pullup to U1.
W2-1 to W2-2	Open *	1	When closed, connects +5 VDC S pullup to U2.
W2-2 to W2-3	Open	1	When closed, connects +15 VDC E pullup to U2.
W3-1 to W3-2	Open *	1	When closed, connects +5 VDC S pullup to U5.
W3-2 to W3-3	Open	1	When closed, connects +15 VDC E pullup to U5.
W4-1 to W4-2	Open *	1	When closed, connects +5 VDC S pullup to U6.
W4-2 to W4-3	Open	1	When closed, connects +15 VDC E pullup to U6.
W6-1 to W6-2	Open *	1	When closed, connects +5 VDC S pullup to U17.
W6-2 to W6-3	Open	1	When closed, connects +15 VDC E pullup to U17.
W7-1 to W7-2	Open *	1	When closed, connects +5 VDC S pullup to U16.
W7-2 to W7-3	Open	1	When closed, connects +15 VDC E pullup to U16.
W8-1 to W8-2	Open *	1	When closed, connects +5 VDC S pullup to U12.
W8-2 to W8-3	Open	1	When closed, connects +15 VDC E pullup to U12.
W9-1 to W9-2	Open *	1	When closed, connects +5 VDC S pullup to U9.
W9-2 to W9-3	Open	1	When closed, connects +15 VDC E pullup to U9.
W10-1 to W10-2	Open *	1	When closed, connects +5 VDC S pullup to U11.
W10-2 to W10-3	Open	1	When closed, connects +15 VDC E pullup to U11.
W11-1 to W11-2	Open *	1	When closed, connects +5 VDC S pullup to U10.
W11-2 to W11-3	Open	1	When closed, connects +15 VDC E pullup to U10.
W13-1 to W13-2	Open *	1	When closed, connects INT2A to INT2B.
W14-1 to W14-2	Closed *	1	Provides GND to sockets of Port 1A and Port 1B.
W14-2 to W14-3	Open	1	When closed, provides +5 VDC to sockets of Port 1A and Port 1B.
W14-2 to W14-4	Open	1	When closed, connects the output of the Control Fail Circuit to the sockets of Port 1A and Port 1B.
W15-1 to W15-2	Open	1	When closed, connects INT2B to INT1A.
W16-1 to W16-2	Open	1	When closed, connects INT1A to CIMBUS interrupt line INT4.
W16-1 to W16-3	Open	1	When closed, connects INT1A to CIMBUS interrupt line INT5.
W18-1 to W18-2	Open	1	When closed, connects INT2A to INT1B
W19-1 to W19-2	Open	1	When closed, connects INT2B to CIMBUS interrupt line INT2.
W19-1 to W19-3	Open	1	When closed, connects INT2B to CIMBUS interrupt line INT3.
W20-1 to W20-2	Open	1	When closed, provides +5 VDC to sockets of Port 2A and Port 2B.
W20-2 to W20-3	Closed *	1	Provides GND to sockets of Port 2A and Port 2B.
W20-2 to W20-4	Open	1	When closed, connects the output of the Control Fail Circuit to the sockets of Port 2A and Port 2B.
W21-1 to W21-2	Open	1	When closed, connects INT1A to INT1B.
W23-1 to W23-2	Closed *	1	Provides GND to sockets of all port Strobe and Ready lines.
W23-2 to W23-3	Open	1	When closed, provides +5 VDC to sockets of all port strobe and ready lines.
W23-2 to W23-4	Open	1	When closed, connects the output of the Control Fail Circuit to the sockets of all port strobe and ready lines.
W24-1 to W24-2	Closed *	1	Connects the inverted output of the Control Fail Circuit, FAIL, which generates FI/ and FA/.
W24-2 to W24-3	Open	1	When closed, connects the output of the Control Fail Circuit, FAIL/, which generates FI and FA.
W25-1 to W25-2	Open	1	When closed, connects INT2A to CIMBUS interrupt line INT0.
W25-1 to W25-3	Open	1	When closed, connects INT2A to CIMBUS interrupt line INT1.
W26-1 to W26-2	Open	1	When closed, connects -15 VDC from the CIMBUS interface to connector J1 pin 50.
W27-1 to W27-2	Open	1	When closed, connects INT1B to CIMBUS interrupt line INT6.
W27-1 to W27-3	Open	1	When closed, connects INT1B to CIMBUS interrupt line INT7.
W28-1 to W28-2	Open	1	When closed, PIO's are cleared when CIMBUS INHIBIT/ line is asserted.
W28-2 to W28-3	Closed *	1	PIO's are cleared when the output of the Control Fail Circuit is active (FAIL/).
W28-2 to W28-4	Open	1	When closed, PIO's are cleared when CIMBUS RESET/ line is asserted.
W29-1 to W29-2	Closed *	1	Provides +5 VDC supply voltage for all sockets (+5 V S).
W29-2 to W29-3	Open	1	When closed, provides external +5 VDC from connector J1 pin 44 to all sockets (supply voltage).
W30-1 to W30-2	Open	1	When closed, connects CIMBUS analog GND to connector J1 pins 47 and 48.
W31-1 to W30-2	Open	1	When closed, connects +15 VDC from the CIMBUS interface to the board and connector J1 pin 49.
W32-1 to W32-2	Closed *	1	Connects the CIMBUS GND line to all socket grounds (GND S).
W32-2 to W32-3	Open	1	When closed, connects external GND from connector J1 Pins 21, 22, 43, and 45 to all socket grounds (GND S).
W33-1 to W33-2	Open *	1	When closed, connects CIMBUS GND to external GND (connector J1, pins 21, 22, 43, and 45).
W34-1 to W34-2	Open	1	When closed, connects external +5 VDC (J1, pin 44) to the CIMBUS +5 VDC

ADDRESS ASSIGNMENTS

JUMPERS W5	W22	W17	BASE ADDRESS
W5-1 to W5-9	W22-1 to W22-2	W17-1 to W17-2	00H
W5-1 to W5-9	W22-1 to W22-2	W17-2 to W17-3	08H
W5-1 to W5-9	W22-2 to W22-3	W17-1 to W17-2	10H
W5-1 to W5-9	W22-2 to W22-3	W17-2 to W17-3	18H
W5-2 to W5-10	W22-1 to W22-2	W17-1 to W17-2	20H
W5-2 to W5-10	W22-1 to W22-2	W17-2 to W17-3	28H
W5-2 to W5-10	W22-2 to W22-3	W17-1 to W17-2	30H
W5-2 to W5-10	W22-2 to W22-3	W17-2 to W17-3	38H
W5-3 to W5-11	W22-1 to W22-2	W17-1 to W17-2	40H
W5-3 to W5-11	W22-1 to W22-2	W17-2 to W17-3	48H
W5-3 to W5-11	W22-2 to W22-3	W17-1 to W17-2	50H
W5-3 to W5-11	W22-2 to W22-3	W17-2 to W17-3	58H
W5-4 to W5-12	W22-1 to W22-2	W17-1 to W17-2	60H
W5-4 to W5-12	W22-1 to W22-2	W17-2 to W17-3	68H
W5-4 to W5-12	W22-2 to W22-3	W17-1 to W17-2	70H
W5-4 to W5-12	W22-2 to W22-3	W17-2 to W17-3	78H
W5-5 to W5-12	W22-1 to W22-2	W17-1 to W17-2	80H **
W5-5 to W5-12	W22-1 to W22-2	W17-2 to W17-3	88H **
W5-5 to W5-12	W22-2 to W22-3	W17-1 to W17-2	90H **
W5-5 to W5-12	W22-2 to W22-3	W17-2 to W17-3	98H **
W5-6 to W5-11	W22-1 to W22-2	W17-1 to W17-2	A0H **
W5-6 to W5-11	W22-1 to W22-2	W17-2 to W17-3	A8H
W5-6 to W5-11	W22-2 to W22-3	W17-1 to W17-2	B0H
W5-6 to W5-11	W22-2 to W22-3	W17-2 to W17-3	B8H
W5-7 to W5-10	W22-1 to W22-2	W17-1 to W17-2	C0H
W5-7 to W5-10	W22-1 to W22-2	W17-2 to W17-3	C8H
W5-7 to W5-10	W22-2 to W22-3	W17-1 to W17-2	D0H
W5-7 to W5-10	W22-2 to W22-3	W17-2 to W17-3	D8H
W5 9 to W5-9	W22-1 to W22-2	W17-1 to W17-2	E0H
W5-8 to W5-9	W22-1 to W22-2	W17-2 to W17-3	E8H
W5-8 to W5-9	W22-2 to W22-3	W17-1 to W17-2	F0H
W5-8 to W5-9	W22-2 to W22-3	W17-2 to W17-3	F8H

*-Indicates a jumpered connection.

**-Indicates base address for board 1-5 respectively.

Figure 2.1-9. Parallel I/O board jumper configuration.

TABLE 2.1-1. I/O PORT ASSIGNMENTS

PORT	OPERATION	
	READ	WRITE
BASE + 0	UNUSED	RESET PIO1
BASE + 1	STATUS PIO1	CONTROL PIO1
BASE + 2	A INPUT PIO1	A OUTPUT PIO1
BASE + 3	B INPUT PIO1	B OUTPUT PIO1
BASE + 4	UNUSED	RESET PIO2
BASE + 5	STATUS PIO2	CONTROL PIO2
BASE + 6	A INPUT PIO2	A OUTPUT PIO2
BASE + 7	B INPUT PIO2	B OUTPUT PIO2

2.1.2 VPR Software

Thus far, insight has been given into the hardware of the VPR, but the VPR is an integration of hardware and software. A more complete description is shown in Figure 2.1-10. In this figure, which points out the software intensiveness of the VPR, the hardware is at the lowest level. The system is built on levels with hardware and hardware-dependent software at the lower levels, and application programs at the upper levels.

The functions of the VPR are like building blocks, with each level making use of the functions provided by the level below.

The VPR is designed around a commercially available real-time operating system kernal called Versatile Real-Time Executive (VRTX). VRTX provides the facilities necessary for:

a. Task management.

b. Inter-task communication and synchronization.

c. Character I/O support.

d. Interrupt servicing.

2.1.2 (Cont'd)

Table 2.1-2 lists the various VRTX calls.

TABLE 2.1-2. VRTX CALLS

Group	Mnemonic	Function
Task Management:	SC_TCREATE	Task create
	SC_TDELETE	Task delete
	SC_TSUSPEND	Task suspend
	SC_TRESUME	Task resume
	SC_TPRIORITY	Task priority change
	SC_TINQUIRY	Task inquiry
	SC_LOCK	Disable task rescheduling
	SC_UNLOCK	Enable task rescheduling
Communication and Synchronization:		
	SC_POST	Post message
	SC_PEND	Post for message
	SC_ACCEPT	Accept message
	SC_QPOST	Post message to queue
	SC_QPEND	Pend message from queue
	SC_QACCEPT	Accept message from queue
	SC_QCREATE	Create message queue
Real-Time Clock:	SC_TDELAY	Task delay
	SC_TSLICE	Enable round-robin scheduling
Character I/O:	SC_GETC	Get character
	SC_PUTC	Put character
	SC_WAITC	Wait character
Interrupt Servicing:		
	UI_POST	Post from interrupt handler
	UI_EXIT	Exit from interrupt handler
	UI_TIMER	Announce timer interrupt
	UI_RXCHR	Received-character interrupt
	UI_TXRDY	Transmit-ready interrupt
	UI_ENTER	Enter interrupt handler
	UI_QPOST	Post to queue from interrupt

Real-Time systems such as the VPR are designed to perform seemingly unrelated functions in a nonsequential manner, thereby utilizing system resources more efficiently. For example, the VPR can interleave the input of data from the parallel I/O boards, mine detonation processing, and display of data on the terminal. VRTX supports these real-time functions by providing the basic mechanism for implementing, multitasking, where a task is a complete execution path through code that demands the use of system resources. In real-time systems, several tasks appear to operate simultaneously through rapid allocation of CPU time.

2.1.2 (Cont'd)

In the VPR, as many as three tasks, each tagged with a unique identification number, is active at one time. (The operating system kernel supports and the VPR could contain up to 255 tasks.) Each task is assigned a priority level, with control of the CPU being given to the highest priority task that is ready to execute. Tasks can create other tasks, as well a delete, suspend, and change the priority of themselves or other tasks.

In a multitask environment, tasks exist in one of the four following states:

a. Executing - The task has control of the CPU and is executing its assigned instruction path.

b. Ready - The task is ready for execution but cannot gain control of the CPU until: (1) all higher priority tasks existing in the ready or executing state are either completed or suspended, and (2) it reaches the head of the queue of equal priority tasks.

c. Suspended - The task has been suspended mid-execution and is waiting to be readied by a system call or an event (e.g., a certain number of ticks expires or a special character arrives).

d. Dormant - The task has not been initiated, or its execution has been completed and it is now idle.

Figure 2.1-10 summarizes the task state transition.

A task may become suspended for any of the following reasons:

a. A Task Suspended call, SC_TSUSPEND, was issued specifying that task (either by priority or ID number).

b. The task suspended itself for a specified time delay using the SC_TDELAY call.

c. The task is waiting for a message from another task or interrupt handler (i.e., it issued an SC_PEND or SC_QPEND call but no message is posted yet).

d. The task issued an SC_WAITC call and is waiting for a special character to be sent from an I/O device.

e. The task issued an SC_GETC call, but the input buffer maintained by VRTX was empty, so it is waiting for input from an I/O device.

f. The task issued an SC_PUTC call, but the output buffer was full, so it is waiting to output to an I/O device.

Just as a number of different events may suspend a task, several events and calls can place a suspended task back in the ready state.

a. An SC_TRESUME call can be issued to ready a task that was suspended by an SC_TSUSPEND call.

2.1.2 (Cont'd)

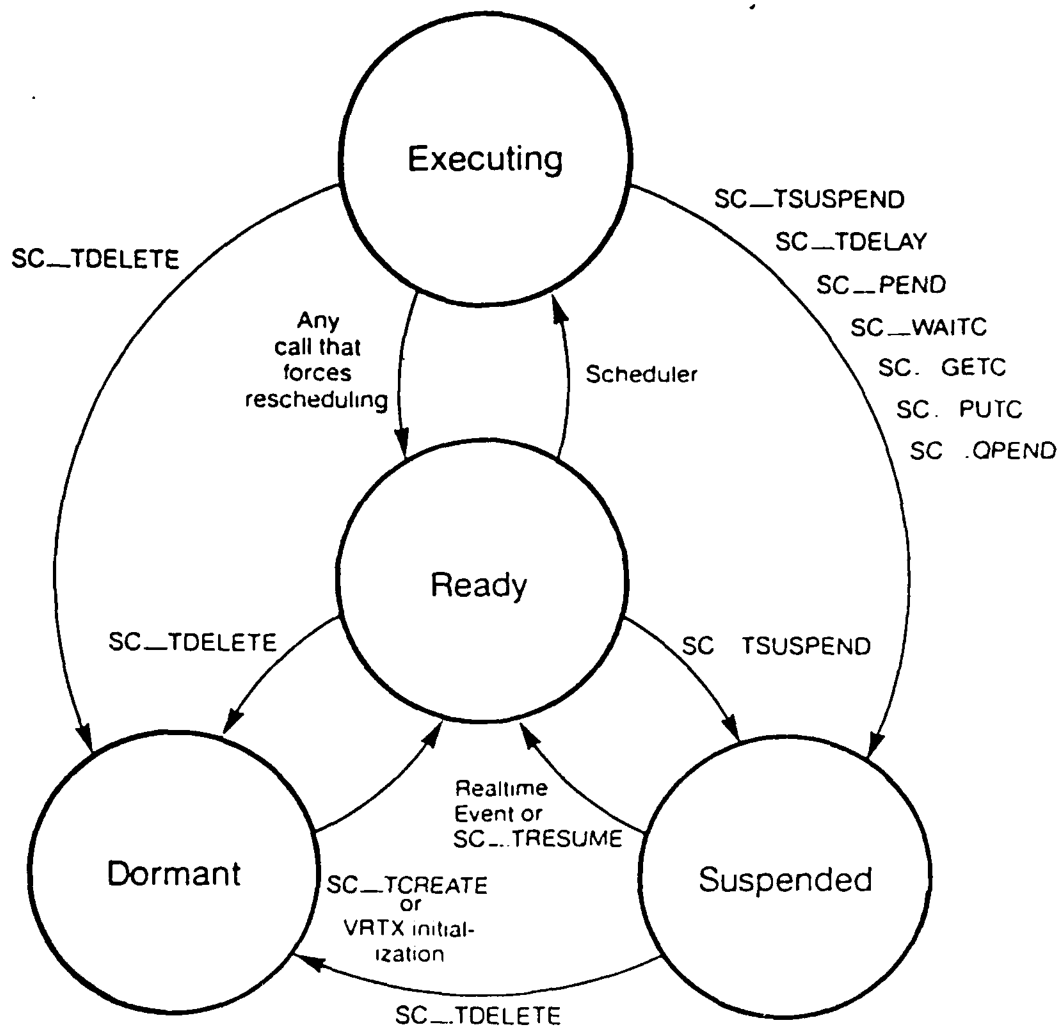


Figure 2.1.10. Summary of task state transition.

2.1.2 (Cont'd)

b. A time delay can expire, thus readying a task that was either suspended by an SC_TDELAY call or timed out pending for a message.

c. A message can be posted (via an SC_POST, SC_QPOST, UI_POST, or UI_QPOST call) to a task that is waiting for a message.

d. A special character can be sent (via a UI_RXCHR call from an interrupt service routing) to a task that was suspended by an SC_WAITC call.

e. Characters can be sent to the input buffer from an interrupt service routine using the UI_RXCHR call; any tasks that were suspended on an empty buffer are then readied.

f. Characters can be removed from the output buffer by an interrupt service routine using the UI_TXRDY call; any tasks that were suspended on a full buffer are then readied.

In the VPR, VRTX is augmented by various software modules to provide the operating system environment (refer to fig. 2.1-11). These range from the most primitive, i.e., device drivers and interrupt handlers which embody the unique timing and control signal manipulation of the various hardware elements, to the high level applications tasks. Intermediate levels contain the command processors, utility and I/O processors, as well as VRTX and its extensions. The following paragraphs provide a discussion of the applications tasks.

The operator interfaces to the VPR through a keyboard monitor (VPR_SYS) task which is created during, and given control following power up initialization. The Warnier-Orr diagram is shown in Figure 2.1-12. This task controls the mine detonation processing tasks (Mine-chk, Print-mine) along with other functions. These functions include: setting and displaying the current date and time, zeroing and displaying bank memory, displaying the latest revision, setting and displaying the total number of mines to monitor, initializing the parameter used in Mine-chk, resetting detonation data for an individual mine, and displaying detonated mines. The task is in an endless loop waiting for an input from the operator. A two letter mnemonic is entered on the keyboard to invoke the function. It should be noted that to ensure proper data identification, the time should be set prior to starting the mine checking task (Mine-chk).

2.1.2 (Cont'd)

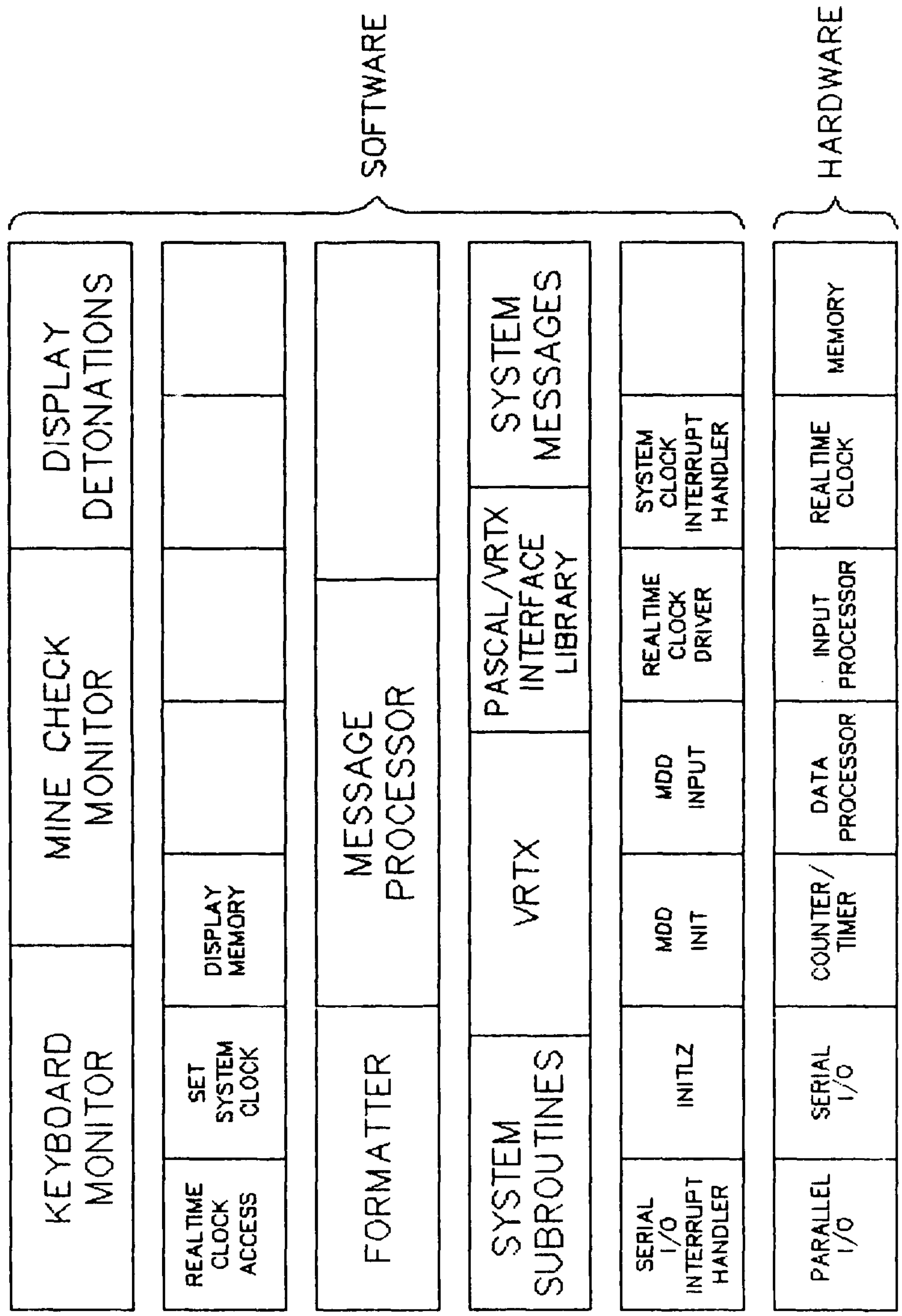


Figure 2.1-11. VPR system topology.

2.1.2 (Cont'd)

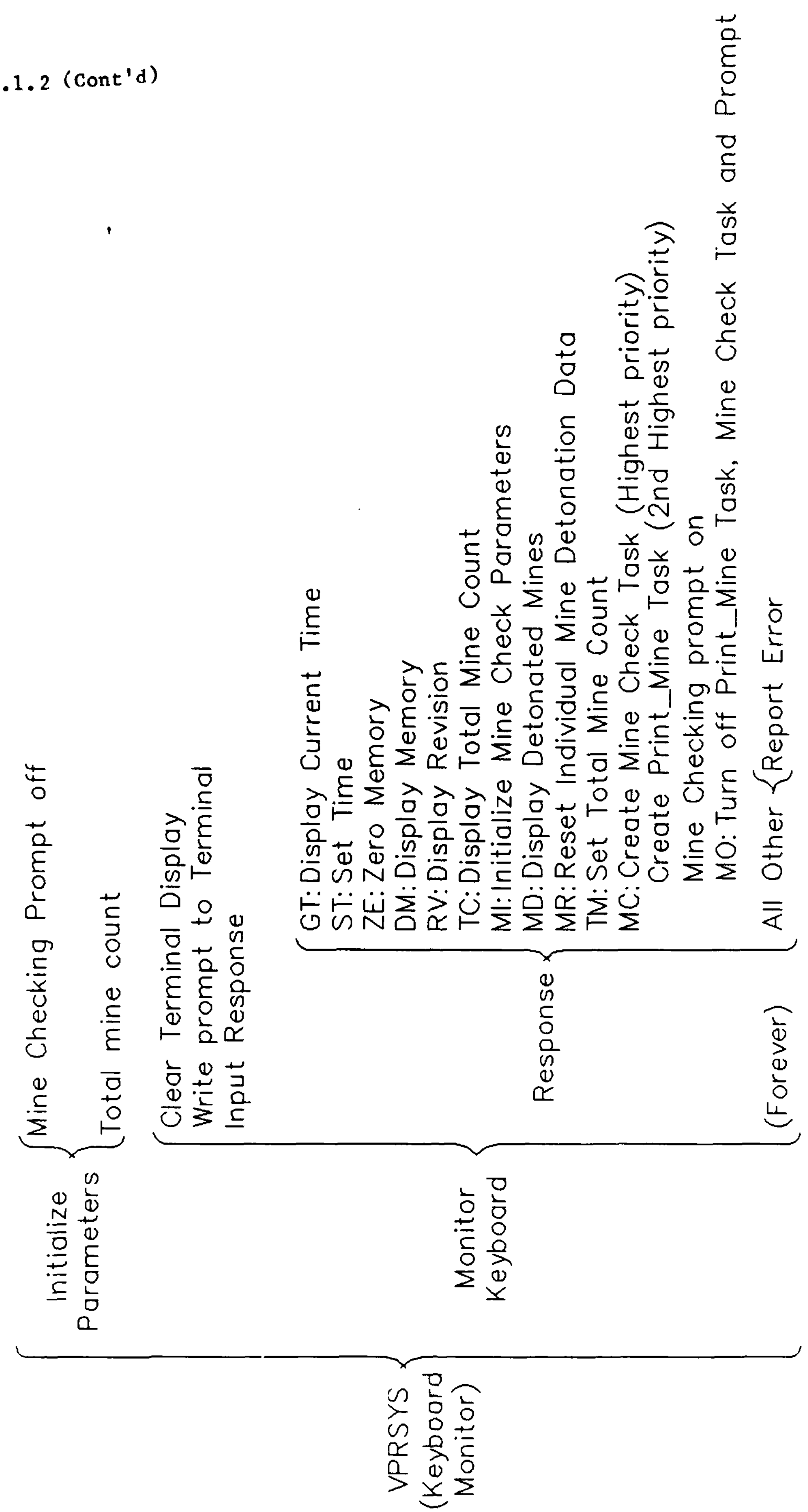


Figure 2.1-12. Warnier-Orr of VPR-System.

2.1.2 (Cont'd)

The Mine_chk task (shown in fig. 2.1-13) is the highest priority task in the system. When this task is created it runs immediately. The task examines the data buffer to determine if a detonation has occured for a particular mine (the buffer being in sequential order of mine number). If a detonation is detected, an array showing the status of the mines is checked to determine if that particular mine has detonated before. A zero in the data buffer indicates a detonation. If it has not, the status of the mine is changed to detonated and the current time is recorded as the time of mine detonation. These detonation times are stored in sequential order and the task is delayed one second before repeating the process.

The Print_mine task (shown in fig. 2.1-14) is the second highest priority task. It was created solely to display detonation times on the terminal and printer. Because of the long time factor involved in printing out the mine detonation times, inaccuracies in the detonation time could occur if the Mine_chk task waited for printing. By having a separate task for printing, Mine_chk does not have to wait for the printing to cease before resuming the monitoring of detonated mines. While the Mine_chk and Print_mine tasks are running, the terminal has an MC_ON: prompt.

The monitoring of the parallel I/O boards is accomplished through the MDDS software routine MDD_INPUT and MDD_INIT. MDD_INIT is invoked in the initialization routine VPR_IO. MDD_INPUT is invoked by a signal from the data processing board. The signal travels via the hardware mailbox every 20 ms. The generation of the signal is the result of a hardware interrupt handling routine called Tick. Tick receives its interrupt from the system clock.

The MDD_INIT routine first sets up the parallel I/O board for Bit Programmable mode, which allows the board's 32 I/O lines and eight status lines to be used as either inputs or outputs. Next these 40 lines are designated as inputs. This is done to all five boards. This set up procedure is accomplished by using a control byte and sending it to the appropriate control register address.

The MDD_INPUT routine reads the data from the input lines by bytes and converts each bit into a byte and stores it into a 200-byte data buffer. The data bytes from the status lines of the two parallel I/O chips (PIO1, PIO2) are added together. For only the upper nibble of each byte is actual data (two strobe and two ready lines). When the irrelevant nibble is masked off and the PIO1 status nibble is shifted down, the two are added together and appropriately stored in the data buffer. The Warnier-Orr diagram of the routines are shown in Figure 2.1-15.

- Mine-chk Task
  - Turn on Mine check prompt
  - Get current time
  - Get mine detonation data
    - Get data buffer
    - Reformat buffer to sequential order (Newdatabuf)
  - Mine number (1,total mines)?1
    - Mine status Mine number =Detonated
    - Detonation time = current time
    - Store order of detonated mines
    - Store detonation times
    - Delay 1 second (SC_TDELAY)
  - (While on)

?1: Mine status of the mine number = undetonated?
Position of mine number in Newdatabuf = 0?

Figure 2.1-13. Warnier-Orr of Mine-chk.

Print–Mine Task

Mine number (1,Total mines)?1

Printed mine status = printed

Display mine number and detonation time and date

(While ON)

?1 Mine status of mine number = detonated
Printed Mine status of mine number = not printed

Figure 2.1-14. Warnier-Orr of Print-mine.

- MDD_INIT — Initialize boards (1,5)
  - Get Board Base Address
  - Reset Board
    - send Control Byte PI01 (Parallel I/O Chip 1)
    - send Control Byte PI02 (Parallel I/O Chip 2)
  - Setup Bit Programmable mode
    - send Control Byte PI01
    - send Control Byte PI02
  - Setup I/O lines as input
    - send Control Byte PI02
    - send Control Byte PI01
  - Setup status lines as input
    - send PI02 Control Bytes
      - Port A
      - Port B
    - send PI01 Control Bytes
      - Port A
      - Port B
  - Increment base address
- MDD_INPUT — Input Board Data (1,5)
  - Get Board's PI01 input register address
  - Input I/O lines data
    - PI01
      - Port A Data Byte
        - Save data
          - Convert each bit to a byte
          - Store into data buffer
      - Port B Data Byte
        - Save data
    - PI02
      - Port A Data Byte
        - Save data
      - Port B Data Byte
        - Save data
  - Input status lines data
    - PI02 status data byte
      - Mask off lower nibble
    - PI01 status data byte
      - Shift upper nibble to lower nibble
      - Mask off upper nibble
    - Add PI01 and PI02 data
      - Save data
  - Increment Base Address

Figure 2.1-15. Warnier-Orr of Mine detonation detection routines.

2.2 TRANSTERM 3 TERMINAL

The Transterm 3 (shown in fig. 2.2-1) communicates with the VPR's data processor using the standard Electronic Industry Association interface (RS-232). The terminal communicates using a serial data format. Each character is transmitted using a leading start bit, seven data bits, a parity bit and one stop bit. The terminal's serial receiver needs to receive only one stop bit for proper operation. The set up for the VPR and terminal is shown in Figure 2.2-2.

The Transterm 3 does not use switches or jumpers to individually enable or disable the features needed for communications with the VPR. Instead, the Transterm 3 uses memory resident flags that may be set or reset in the set-up mode.

The following is the Transterm 3 set-up mode for communications with the VPR. The meaning of each bit of the four groups is shown in Figure 2.2-3.

1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
1 0 1 0 0 0 0 1	0 0 0 0 1 0 0 0	0 0 1 1 0 1 1 1	0 0 0 0 0 0 0 0

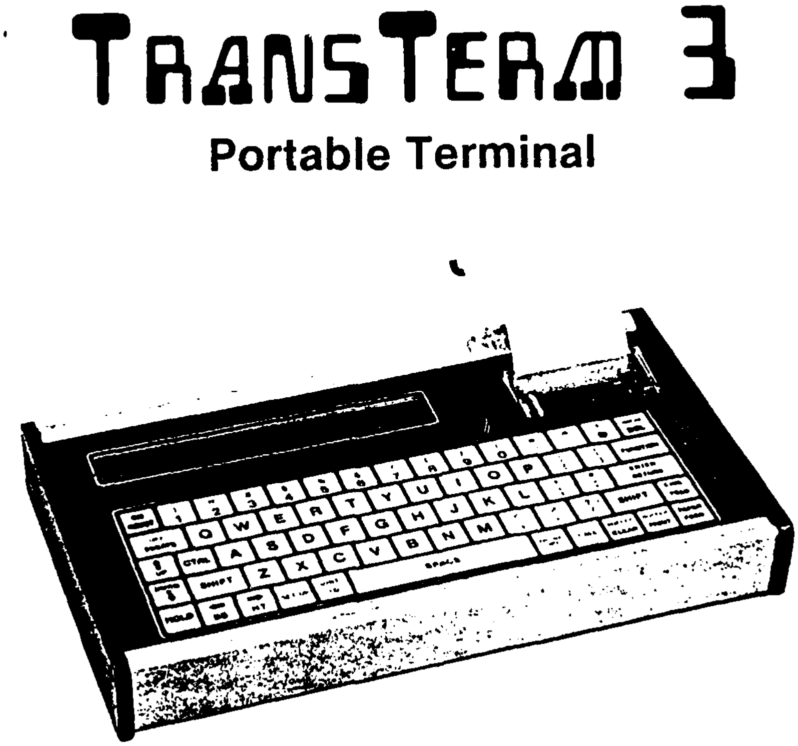


Figure 2.2-1. Transterm 3 with 40 column printer/plotter.

2.2 (Cont'd)

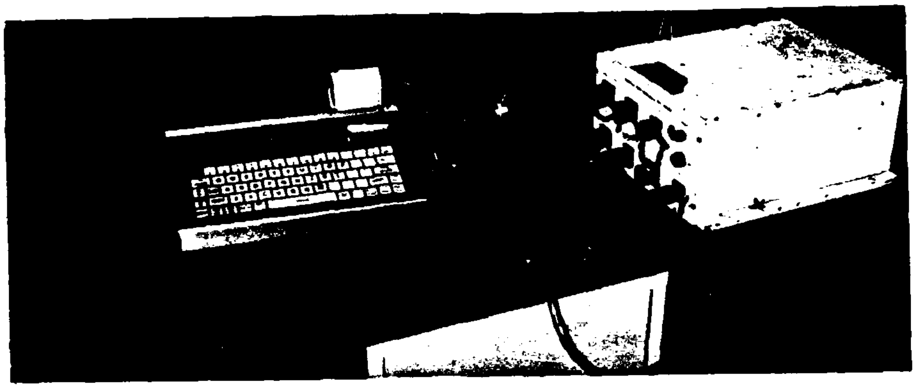


Figure 2.2-2. VPR and terminal setup.

	Group	Flag	Name/Function
	1 1	BR1	Baud rate selection.
	1 2	BR2	Baud rate selection.
	1 3	BR3	Baud rate selection.
	1 4	PS1	Parity selection.
	1 5	PS2	Parity selection.
	1 6	DBF	Display buffer format.
	1 7	PAG	Page mode.
	1 8	LKE	Local keyboard echo.
*	2 1	EXP	Enable XON/OFF protocol.
	2 2	ELW	Enable line wrap.
*	2 3	EKR	Enable key repeat.
	2 4	ENL	Enable new line.
*	2 5	ELN	Enable line number.
	2 6	EPF	Enable protected fields.
*	2 7	EAP	Enable auto-print.
	2 8	ELC	Enable lower case.
	3 1	DPT	Disable printer.
	3 2	DOL	Disable on line (at RESET).
*	3 3	DCS	Disable CTS signal.
*	3 4	DAA	Disable auto answer (M version only).
	3 5	DBL	Disable battery low turn off.
	3 6	DTO	Disable time out turn off.
*	3 7	DPA	Disable phone no. access.
*	3 8	DUA	Disable UID access.
	4 1		Not used.
	4 2		Not used.
	4 3		Not used.
	4 4		Not used.
	4 5		Not used.
	4 6		Not used.
	4 7		Not used.
	4 8		Not used.

* Default Flag values set to "1".

Figure 2.2-3. Brief Flag Summary.

2.2 (Cont'd)

The 40 column printer of Transterm 3 provides a paper copy of information at the terminal. Mine detonations are automatically printed as they occur. Status updates are printed on command.

The DISPLAY is a 2 line 80 character LCD display that serves as a window into the DISPLAY BUFFER memory. It can display 93 standard ASC II characters in a 5 by 7 dot matrix pattern and has a cursor symbol to show character placement. The DISPLAY is also used to display the terminal status and setup parameter values to the operator.

The INPUT BUFFER is a 64 character first in/first out (FIFO) memory used to temporarily hold data which has been received by the communications port. Data are subsequently removed from the input buffer and routed to the DISPLAY BUFFER and the PRINTER.

The BATTERY PACK serves as the power source for the Transterm 3. It consists of self-contained rechargable Ni-Cad batteries that will operate the terminal for about 24 hours on a full charge. It also provides power for the retention of the DISPLAY BUFFER data and the SET-UP parameters in memory when the Transterm 3 is turned OFF.

An example of the data printed by the Transterm appears as Figure 2.2-4.

```
MD
DISPLAY DET MINES BY (1)MINE #, (2)TIME,
(3)RANGE OF MINE #'S, (4)INDIVIDUALLY
(5) OR TOTAL NUMBER?
1
ALL MINES, ORDERED BY #, DETONATED AS
OF 04:10:01:53

#010 04:10:00:28
#004 04:09:23:03
#134 04:09:19:57
TOTAL NUMBER OF MINES = 00003
MC ON:


MD
DISPLAY DET MINES BY (1)MINE #, (2)TIME,
(3)RANGE OF MINE #'S, (4)INDIVIDUALLY
(5) OR TOTAL NUMBER?
1
ALL MINES, ORDERED BY #, DETONATED AS
OF 04:15:14:00

#036 04:15:12:56
#037 04:15:12:58
#039 04:15:12:57
#040 04:15:12:56
#043 04:15:12:57
#045 04:15:12:54
#046 04:15:12:53
#047 04:15:12:52
#049 04:15:12:52
#043 04:15:12:54
#050 04:15:12:55
#053 04:15:12:55
#101 04:15:13:01
#108 04:15:12:55
#117 04:15:13:01
#118 04:15:13:00
TOTAL NUMBER OF MINES = 00016
MC ON:
```

Figure 2.2-4. MDDS data sample.

2.3 MDDS HARDWARE

The MDDS hardware includes all of the hardware used to sense the mine detonation and present a signal representing that occurrence to the VPR.

2.3.1 Sensor with Cable

The sensor was originally designed to be used as the nose cone of the Light Antitank Weapons (LAW) rocket. It is suited for use with the MDDS because it has a piezoelectric crystal inside, that produces a voltage when vibrated. A resistor is placed in parallel with the crystal during fabrication. The nominal resistance of the cone is 130K ohms. The nominal voltage produced when attached to a Volcano Type 20 mine that detonates, is 2 V. The detonation of Type 20 mine produces approximately 460 g's at the surface of the mine. The output signal is shown in Figure 2.3-1.

Each cable is a 100-foot-long jacketed twisted pair. Each pair is stranded 20 AWG wire. Terminal lugs on one end allow easy connections to remote boxes. The other end of the cable is soldered to the sensor's positive and negative terminals. Heat shrink tubing and potting material prevents moisture from shorting the leads. The sensor and cable are shown in Figure 2.3-2.

2.3.1 (Cont'd)

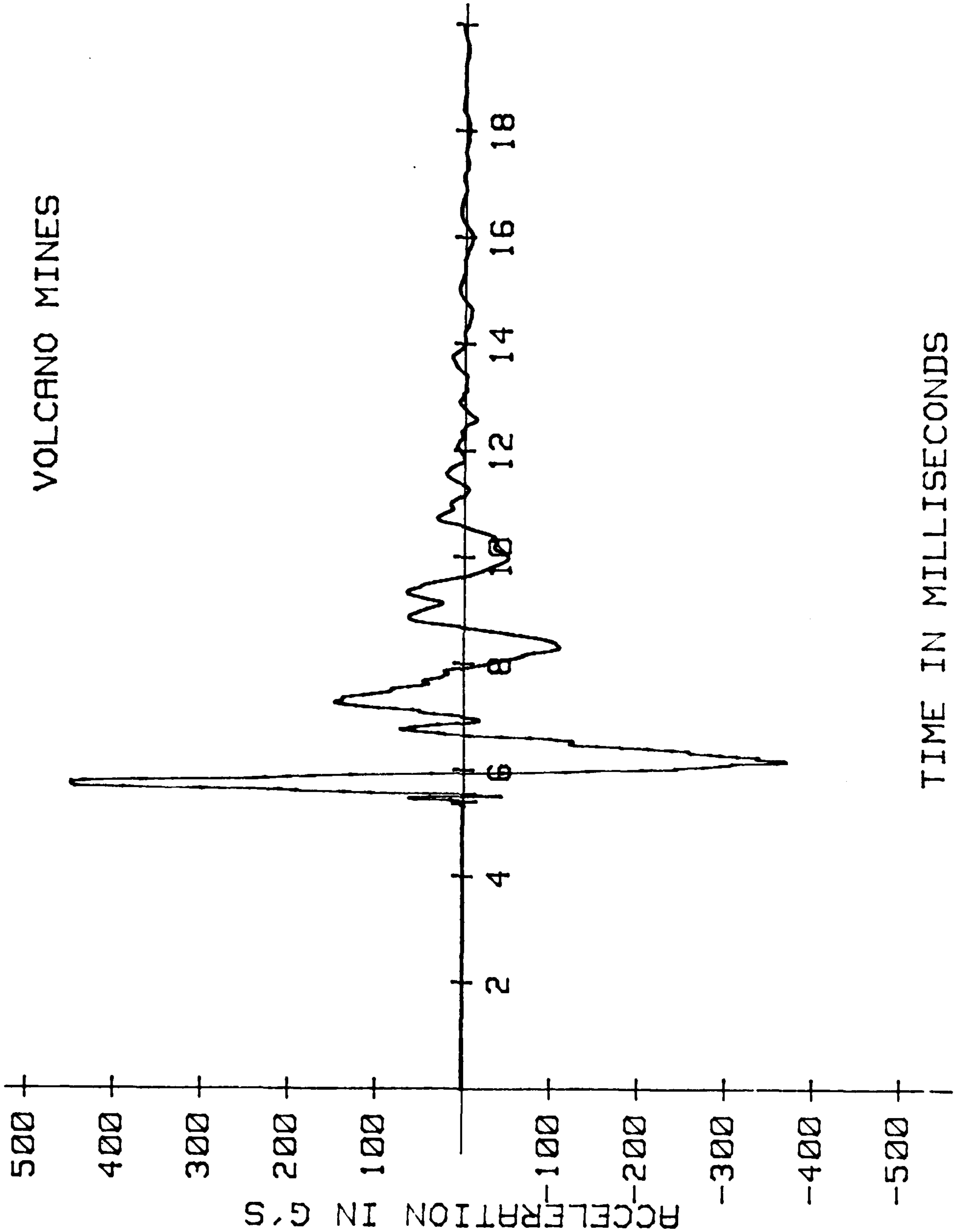


Figure 2.3-1. Acceleration present at the surface of a detonating Type 20 Volcano mine.

2.3.1 (Cont'd)

Figure 2.3-2. Sensor and cable.

2.3.2 Remote box

The remote box (fig. 2.3-3 and 2.3-4) accepts the signals from the sensors and latches whenever that signal goes above a certain threshold.

The output of a sensor is fed into the negative input of a comparator. The positive input to the comparator is connected to a reference voltage. The output of the comparator is the normally high. The comparator's output is connected to one of the set inputs of an RS latch. The reset lines are connected to a pull up resistor that keeps them high. The output of the RS latch is normally low. The latch's output is fed into an inverting line driver. The output of the driver is normally high. The board layout is shown in Figures 2.3-5 and 2.3-6.

When the mine detonates, the vibrations created at the surface cause the sensor to generate a voltage that exceeds the reference. The output of the comparator goes low momentarily. When it does, the RS latch input are "1" and "0" for the R and S inputs, respectively. Looking at the latches truth table below, it is anticipated that the output is going high and staying high even after the S input goes high again.

TRUTH TABLE

S	R	E	Q
X	X	0	High Impedance
0	0	1	0
0	1	1	1
1	0	1	0
1	1	1	No Change

X - Don't Care

The output of the driver goes low and stays there until the latch is reset.

Resetting the latch is accomplished by momentarily grounding the R inputs to the latch (fig. 2.3-7). This results in a "0" and "1" for the R and S inputs of the latch, respectively. The truth table above shows that inputs with those values would cause the output of the latch to go low again. The output of the inverting driver will go high when this happens. Figure 2.3-8 shows the working block diagram of the circuitry.

2.3.2 (Cont'd)

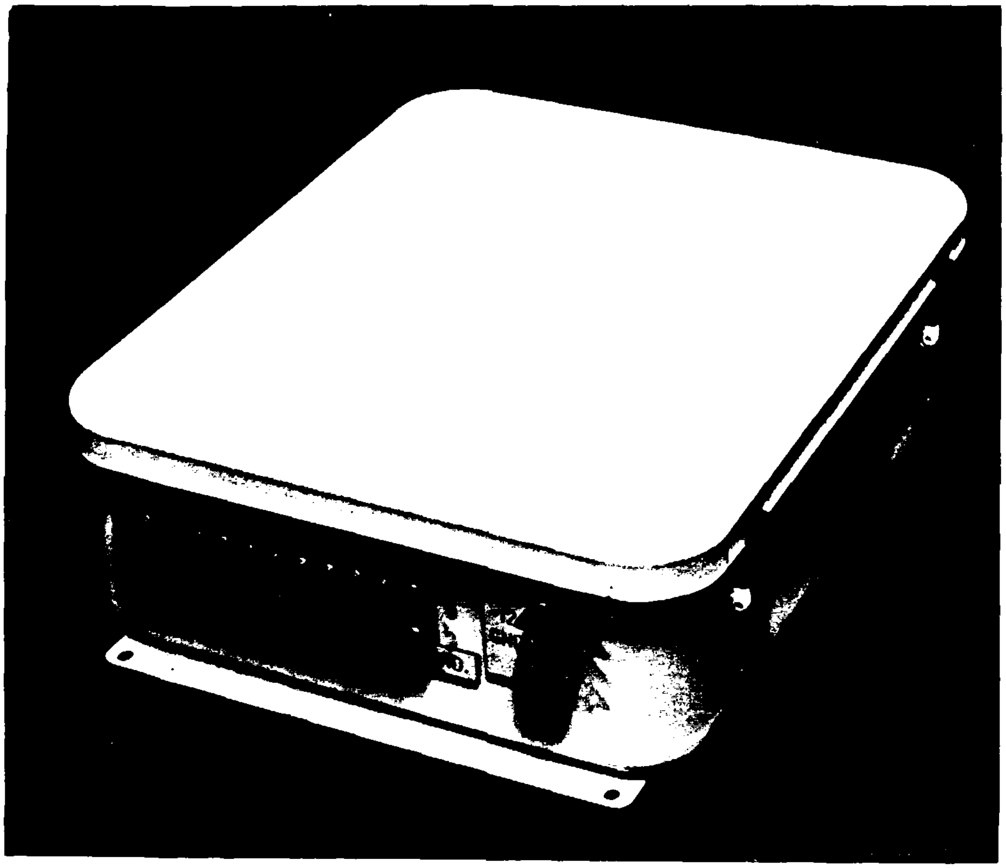


Figure 2.3-3. Remote box.

2.3.2 (Cont'd)

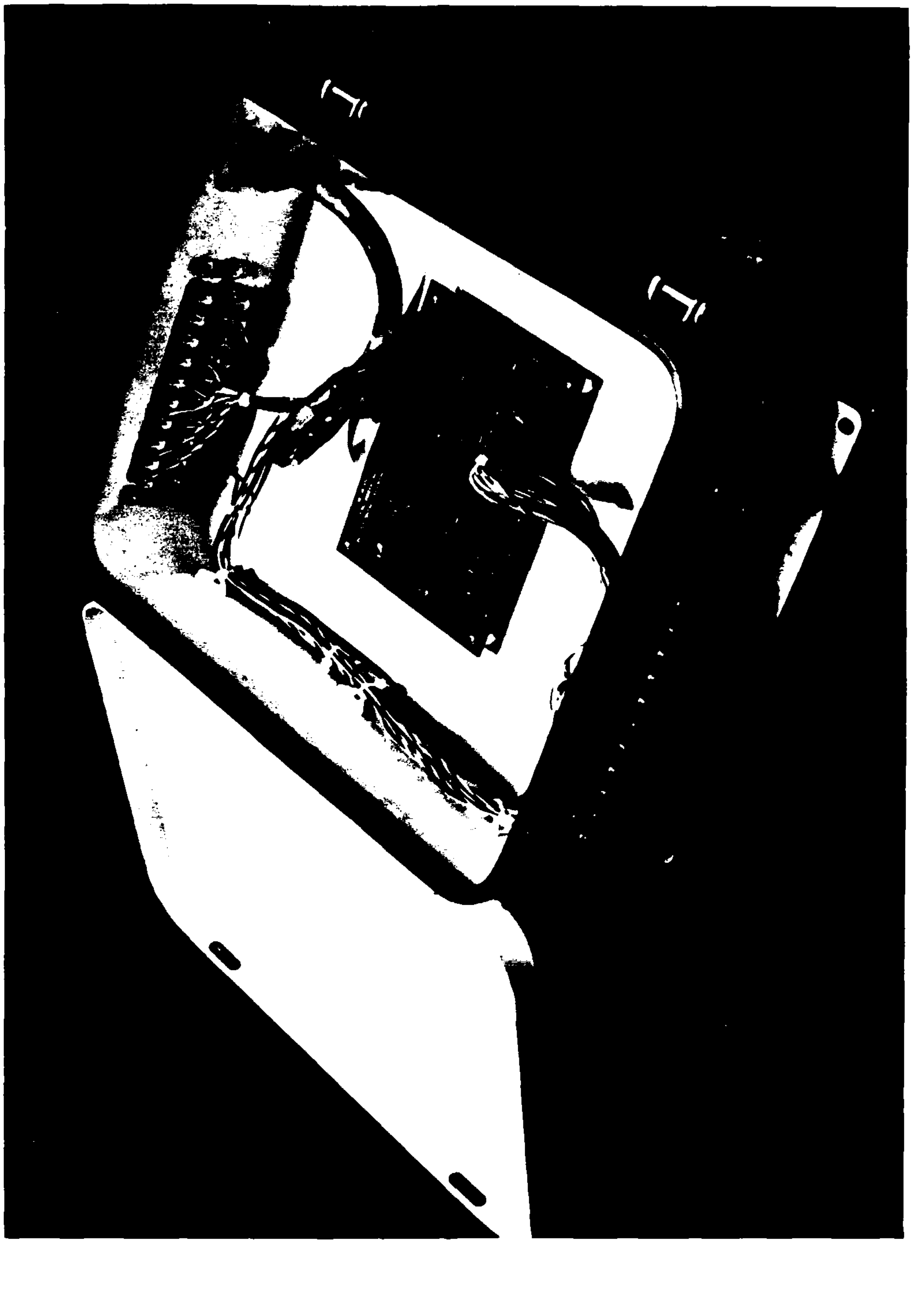


Figure 2.3-4. Internal view of remote box.

2.3.2 (Cont'd)

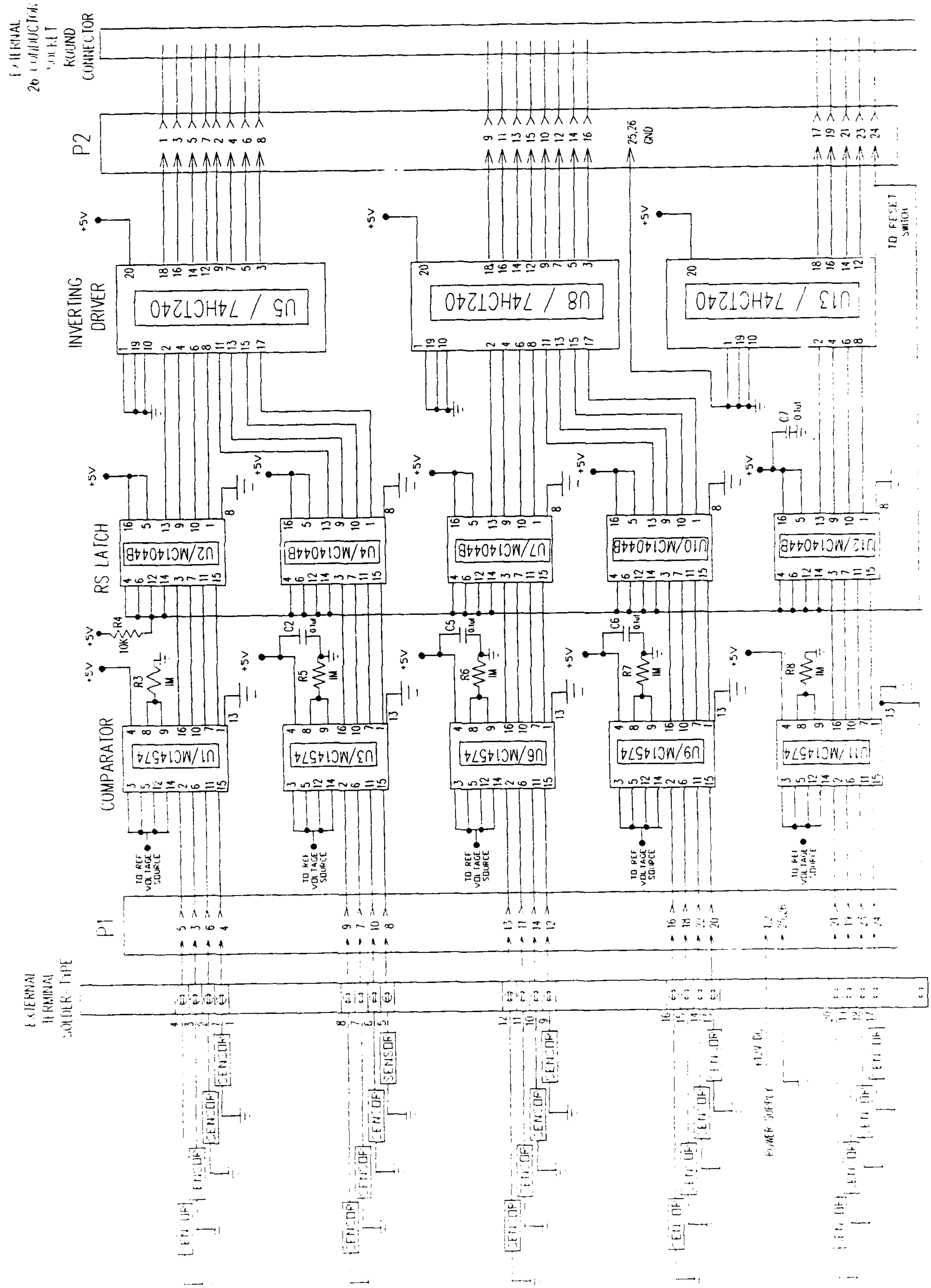


Figure 2.3-5. Remote box schematic.

2.3.2 (Cont'd)

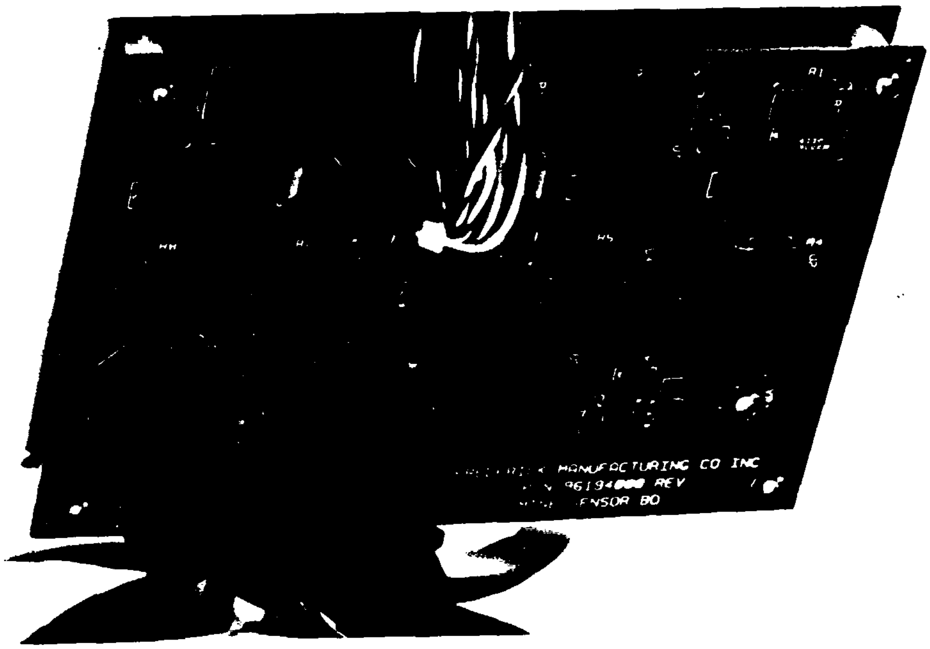


Figure 2.3-6. Remote box circuit board.

2.3.2 (Cont'd)

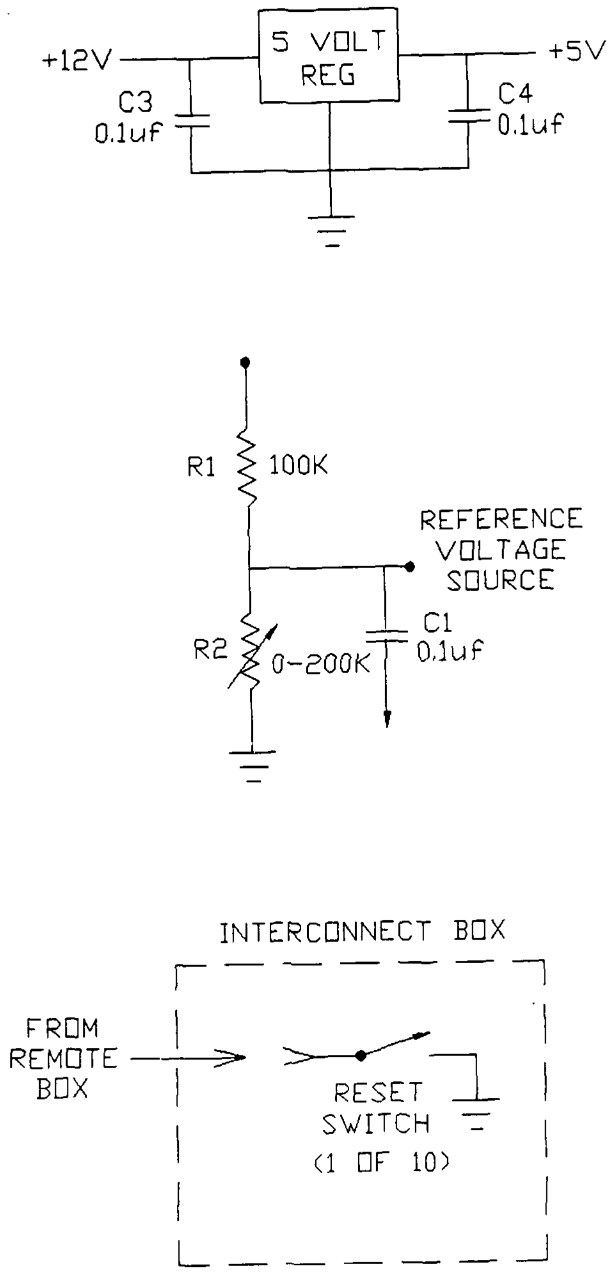
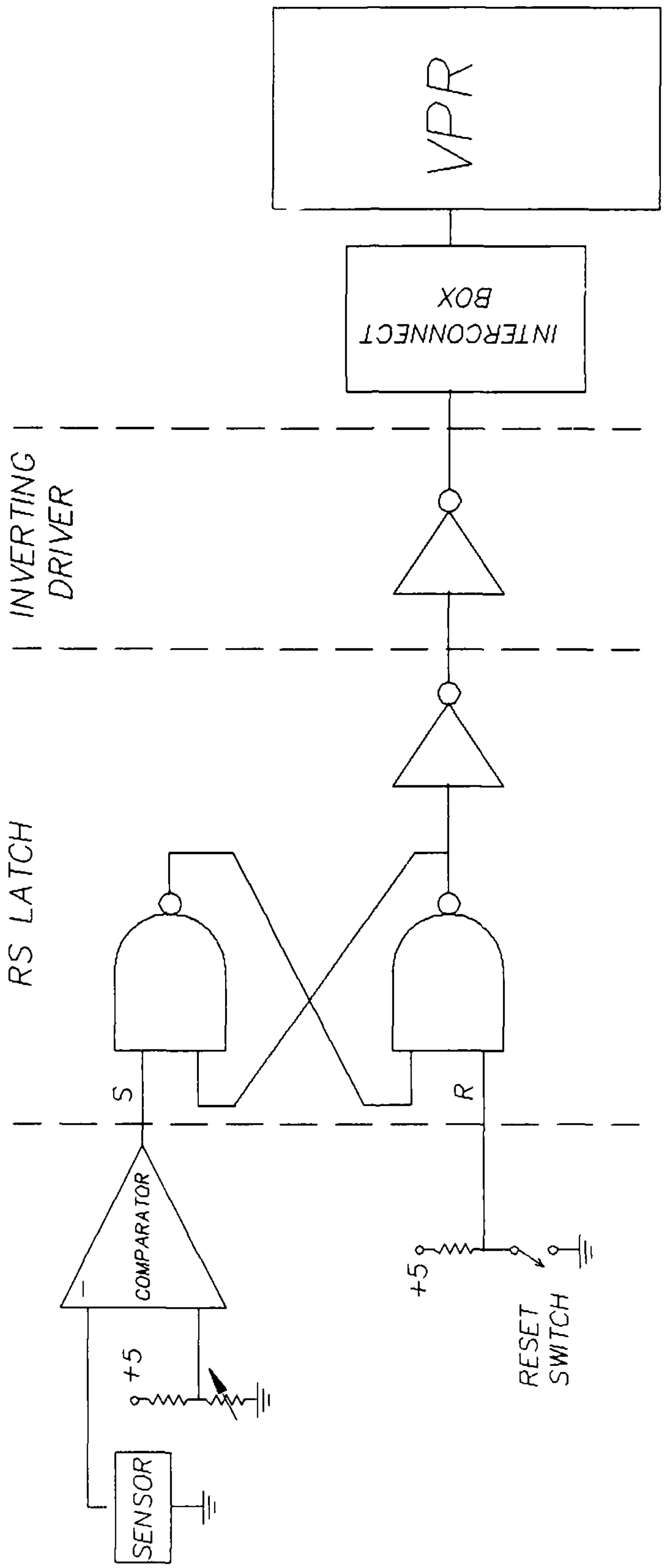


Figure 2.3-7. Supply voltage, reference voltage and reset switch.

2.3.2 (Cont'd)



1 OF 20 SENSOR AND CONDITIONING CIRCUITS PER REMOTE BOX

Figure 2.3-2. Mine detonation sensor and conditioning circuit.

2.3.3 Remote Interconnect Cable and Extender Box

The remote interconnect cable is a jacketed multiconductor cable that is 350 feet in length. Twenty of the conductors are signal lines; one is ground and one is the reset line. The two male cannon connectors on the cable ends allows one end to be connected to a remote box and the other end to an interconnect box or an extender box.

The extender box (fig. 2.3-9) allows the coupling of two remote interconnect cables. The total cable length becomes 700 feet. The two female cannon connectors on the extender box are connected pin to pin inside the box.

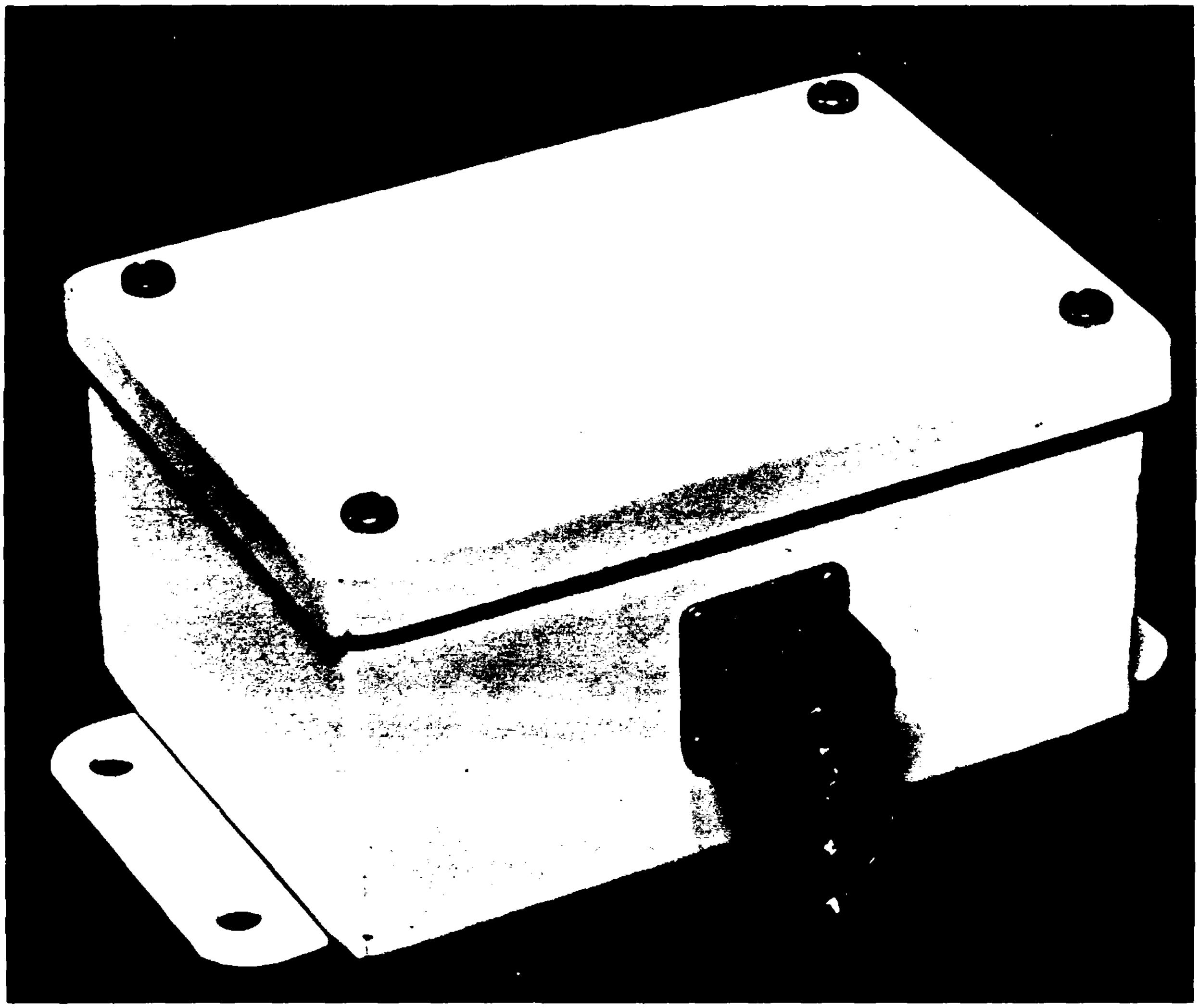


Figure 2.3-9. Extender box.

2.3.4 Interconnect Box

The interconnect box (fig 2.3-10) accepts the ten cables from the remote boxes and provides a hardwire path to ribbon cable connectors. The connectors from two remote boxes are combined and hardwired to one ribbon cable connector. Therefore, only five ribbon cables are required to handle ten cables from the remote boxes. The reset line from each remote box is diverted inside the interconnect box to one pole of a momentary switch that has its other pole connected to ground. Momentarily depressing the switch resets the latches in the corresponding remote box.

Five ribbon cables connect the interconnect box with the VPR. Each ribbon cable is connected to a parallel I/O card that monitors the status of 40 mines. The setup of the interconnect box to the VPR is shown in Figure 2.3-11.

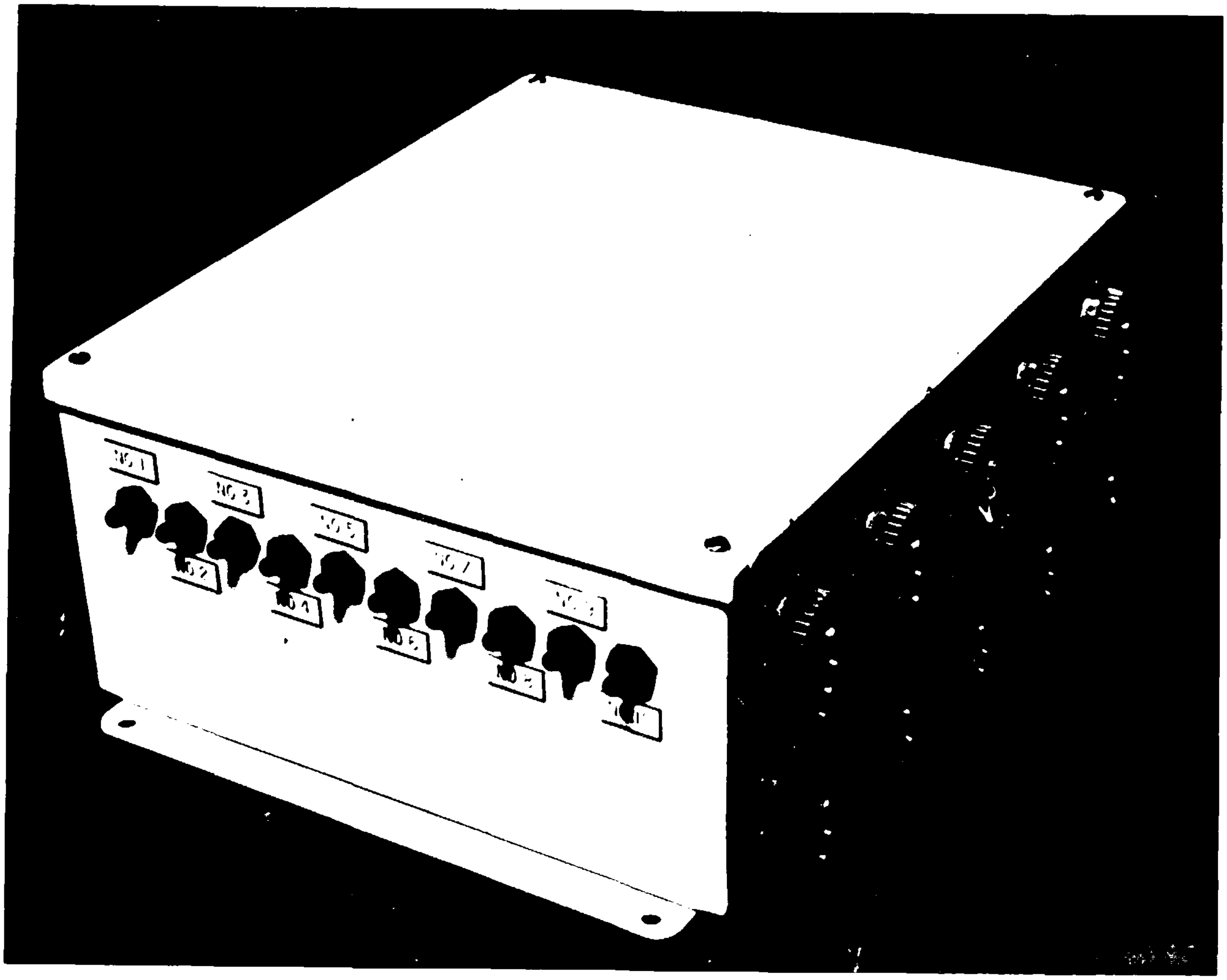


Figure 2.3-10. Interconnect box.

2.3.4 (Cont'd)

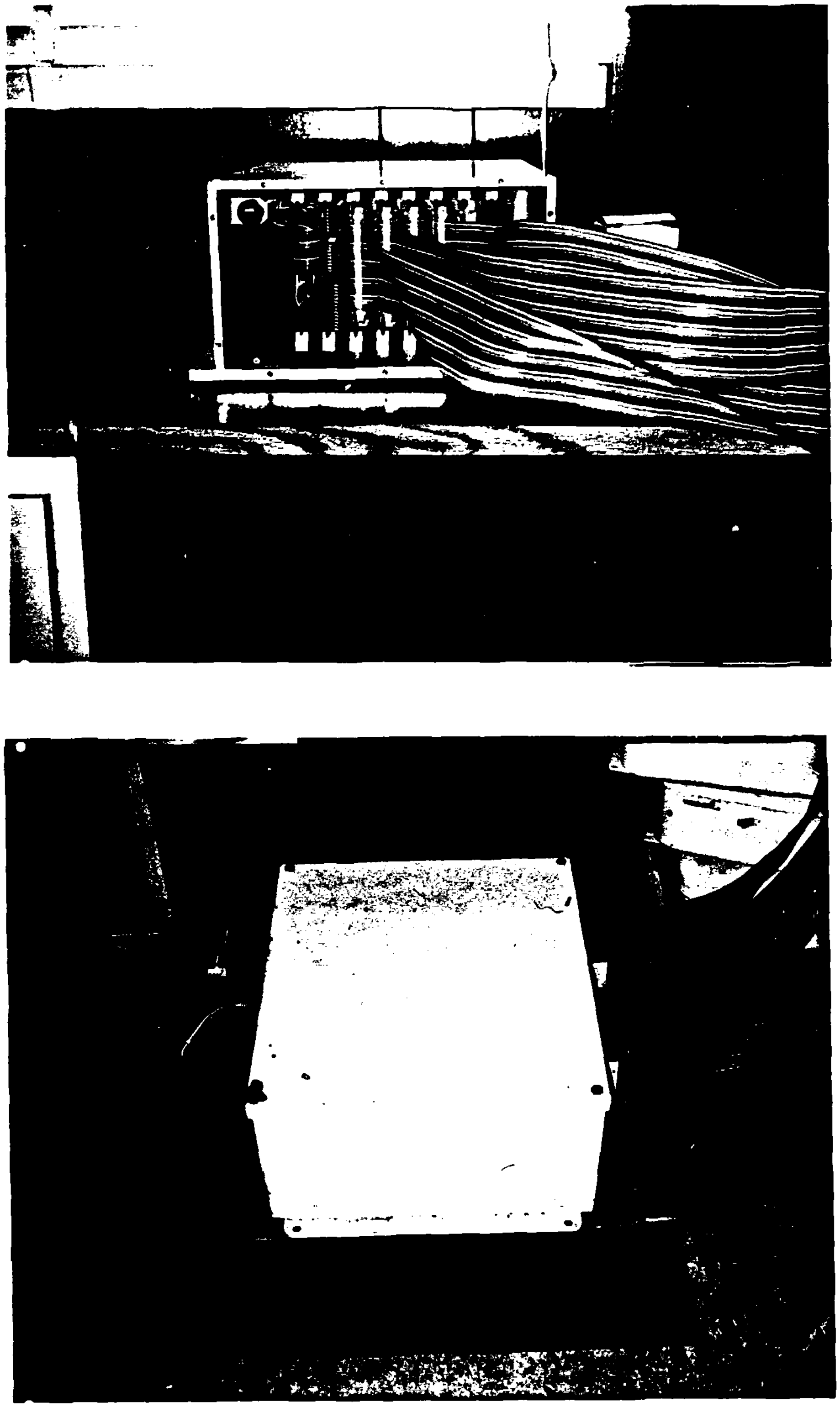


Figure 2.3-11. Ribbon cable connection between the VPR and the interconnect box.

SECTION 3. APPENDICES

APPENDIX A - INSTALLATION INSTRUCTIONS

The instructions detail the preparation and setup of the MDDS for mine testing.

• Test all of the components of the MDDS prior to the start of the test.

-Batteries - charge all batteries prior to the test.

-Sensors - measure the resistance of each sensor at the terminal lugs. The resistance measured should be from 125K to 145K ohms.

-Remote Interconnect Cables - examine the remote interconnect cables for bent pins, bent connectors, gashes in insulation and corrosion. Pay close attention to the part of the connector that provides strain relief when the cable is bent. Insure that this part of the connector fits over the jacket of the cable. Verify the continuity of each of the cable's conductors.

-Remote box - bench test the remote boxes by applying 12 VDC and following the steps below:

• Connect sensors or resistors across the 20 inputs of the remote box.

• Set the threshold by varying R2 and monitoring the voltage at the node between R1 and R2.

• Reset the latches within the remote box by momentarily shorting pins y (gnd) and z (reset line).

• Verify the presence of a logical "1" (4.7-5.0 V) at each of the pins from A to X.

• Set the latches by hitting the sensors or applying a voltage (higher than the reference) to the input terminals.

• Verify the presence of a logical "0" (0.00-0.05 V) at each of the pins from A to X.

• If the box checks out as described above and the steady state current requirement is between 5-15 MA, the box is okay.

-VPR - interconnect box harness test - the continuity of the conductors in the ribbon cables.

-Interconnect box - test the continuity of the conductors between the Cannon connector and the INB/Ansley connector. Use Appendix C as a guide.

• MDDS installation.

-VPR - please follow these steps in the order written. Connect the VPR power cable to the 24 V power supply. Connect the battery terminal lugs to the appropriate battery posts. Plug in the power cord for the power supply. The last step is to connect the power cable to the VPR while the VPR power switch is off.

-Transterm terminal - connect the VPR terminal cable to the VPR and the Transterm. Connect one end of the AC power adapter to the Transterm and the other to a 110-VAC outlet. Press the ON key. Verify the proper setup configuration by entering FUNCTION SET-UP and comparing the display to the following:

10100001 00001000 00110111 00000000

If the displayed configuration matches the one above, press the SET-UP key again. If they do not match use the ← BS and → HT keys to select the bit you want to change. Use the ↑ UP and DOWN ↓ keys to change state of the bit. When the two configurations match, press the SET-UP key again.

-Interconnect box - Connect one end of the VPR interconnect harness to the first parallel I/O card in the VPR. Connect the other end of the harness to position one (INB/Ansley) on the interconnect box. Perform the same procedure for parallel I/O cards 2-5 and interconnect box positions 2-5 (fig. A-1).

-Remote interconnect cables - connect remote interconnect cables to cannon connector positions 1-10 on the interconnect box. Run the 10 cables to the remote boxes in the mine field. If a cable cannot reach a remote box, use a cable extender box (fig. A-2) to connect another reel of remote-interconnect cable.

-Sensors with cable - tie the sensor end of the cable around the stake near the mine (fig. A-3). Run the cable back to the remote box. Connect the terminal lugs of the sensor cable to an open terminal on the remote box. Perform the same procedure with 19 other sensors with cables. If an input is not used tie it to ground with a strand of wire.

-Remote boxes - Check to make sure that the remote interconnect cable and the 20 sensors with cables are connected to the remote boxes. Connect the remote box power cable to the remote box first. Connect the other end of the power cable to the 12 V lead acid battery. Tape a pad or board over the battery to protect against accidental short circuiting of the battery posts. Place the remote box on a wooden box. Put a pad or board on the remote box and the battery on the board. The setup is shown in Figure A-4.

Test the resistance of the cables by putting an ohm meter across each of the 20 sets of terminal inputs on the remote box. The fact that the battery is connected to the remote box will not affect the readings. The resistance measured should be between 125K and 145K ohms. Perform a complete checkout of the system before cementing the sensor to the mine. The complete checkout can be accomplished by performing the initialization procedures in the operator section of this manual, and then tapping each sensor to verify that that a detonation message is printed. Once the checkout is complete, cover everything with something like a garbage can to provide initial protection against the elements. Attach the sensors to the mines with dental cement or some other hole filling adhesive.

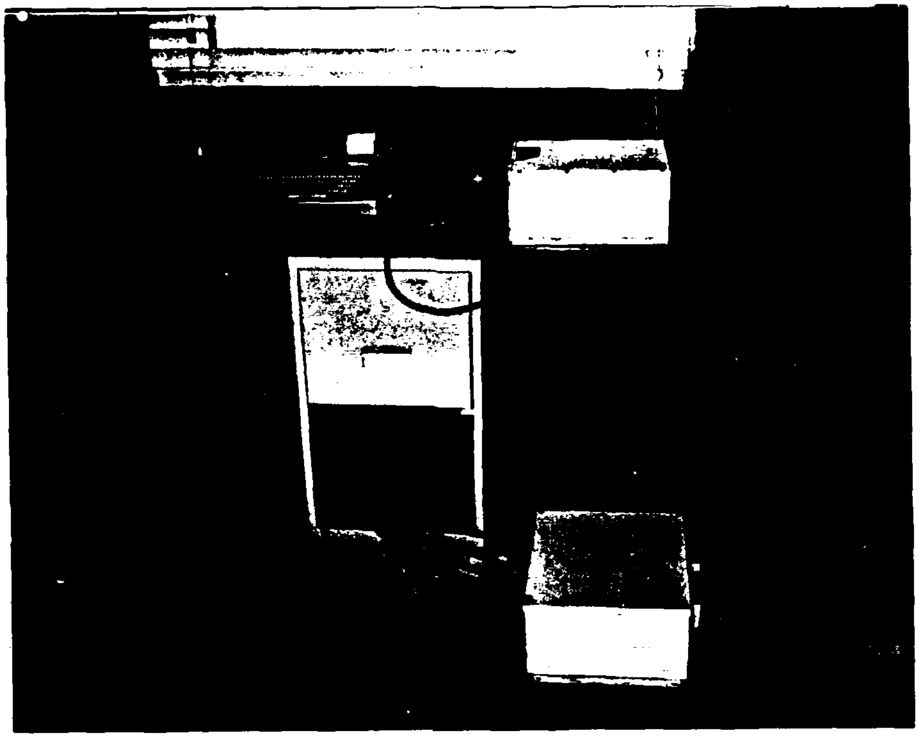


Figure A-1. Monitoring equipment setup.

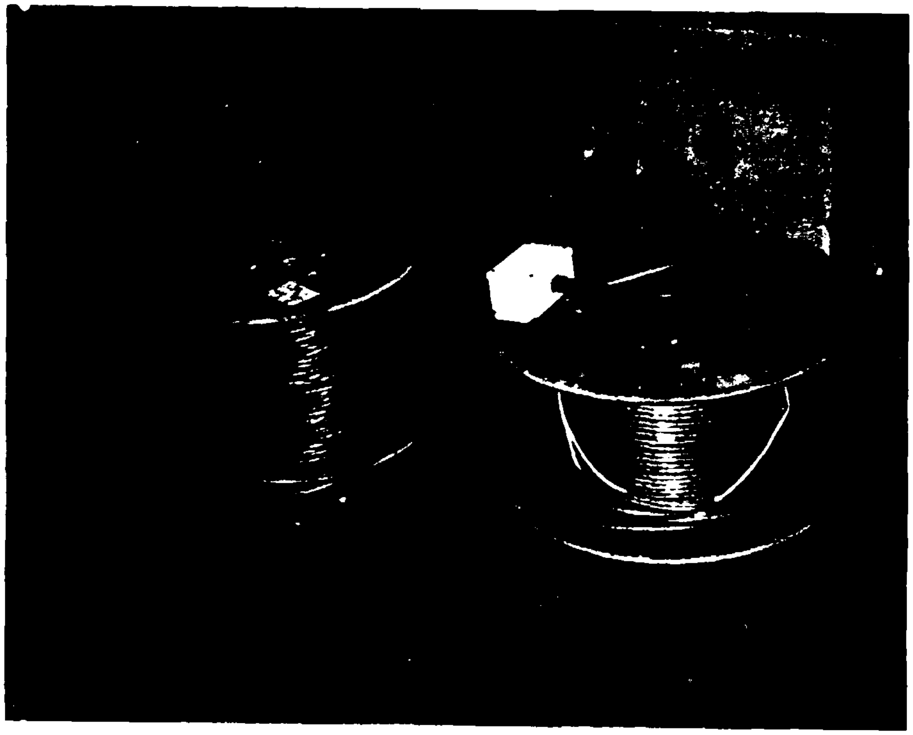


Figure A-2. Cable extender connecting two interconnect cables.

Figure A-3. Sensor with cable.

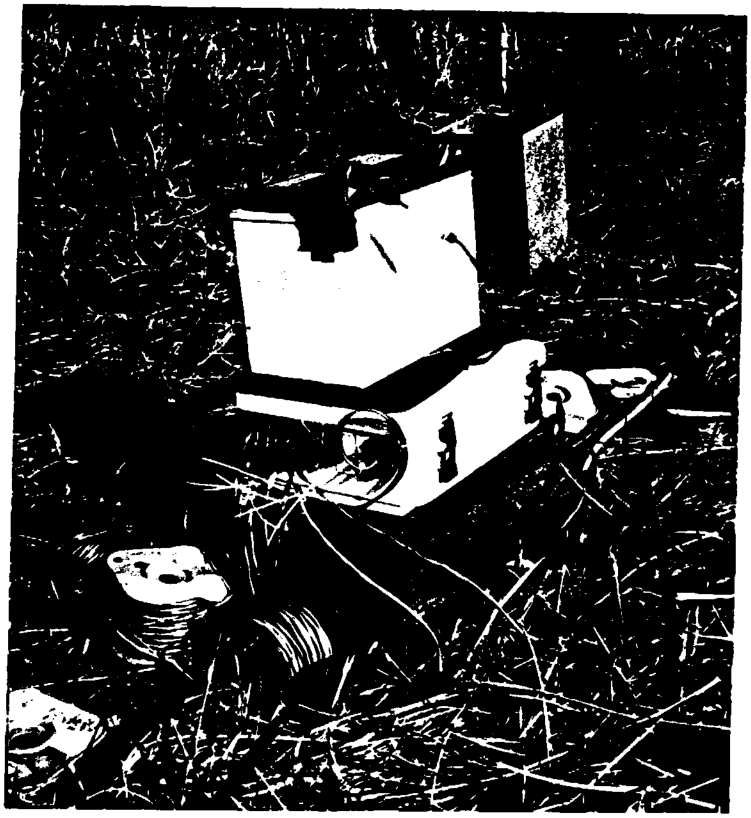


Figure A-4. Recommended field set up for a remote box.

APPENDIX B OPERATOR INSTRUCTIONS

Initialization

a. Turn the VPR power switch to the ON position. Verify that the power light on the face of the VPR comes on (fig. B-1).

b. Depress the red reset switch located on the VPR Terminal cable (RS232 cable) that connects the VPR with the Transterm-3 terminal. Protect the reset button from accidental depression. Depressing the reset button causes the resetting of the CIM-BUS (fig. B-2).

c. Turn the Transterm-3 terminal on by pressing the RESET key. Check to make sure that the VPR prompt comes up on the display. Press RETURN.

d. Set the time by entering the command S T and pressing RETURN. A prompt will appear with the date time format (month: date: hour: minute). Enter the information and press RETURN. Verify the correct time entry by entering the command Q T pressing RETURN and checking the month, date, time and time displayed.

e. Reset all of the remote boxes by depressing the corresponding reset switch on the interconnect box shown in Figure B-3.

f. Initialize the status of the mines by entering the command M I and pressing the RETURN key. The VPR: prompt will reappear.

Figure B-1. Vehicle performance recorder (VPR)

Figure B-2. VPR Terminal

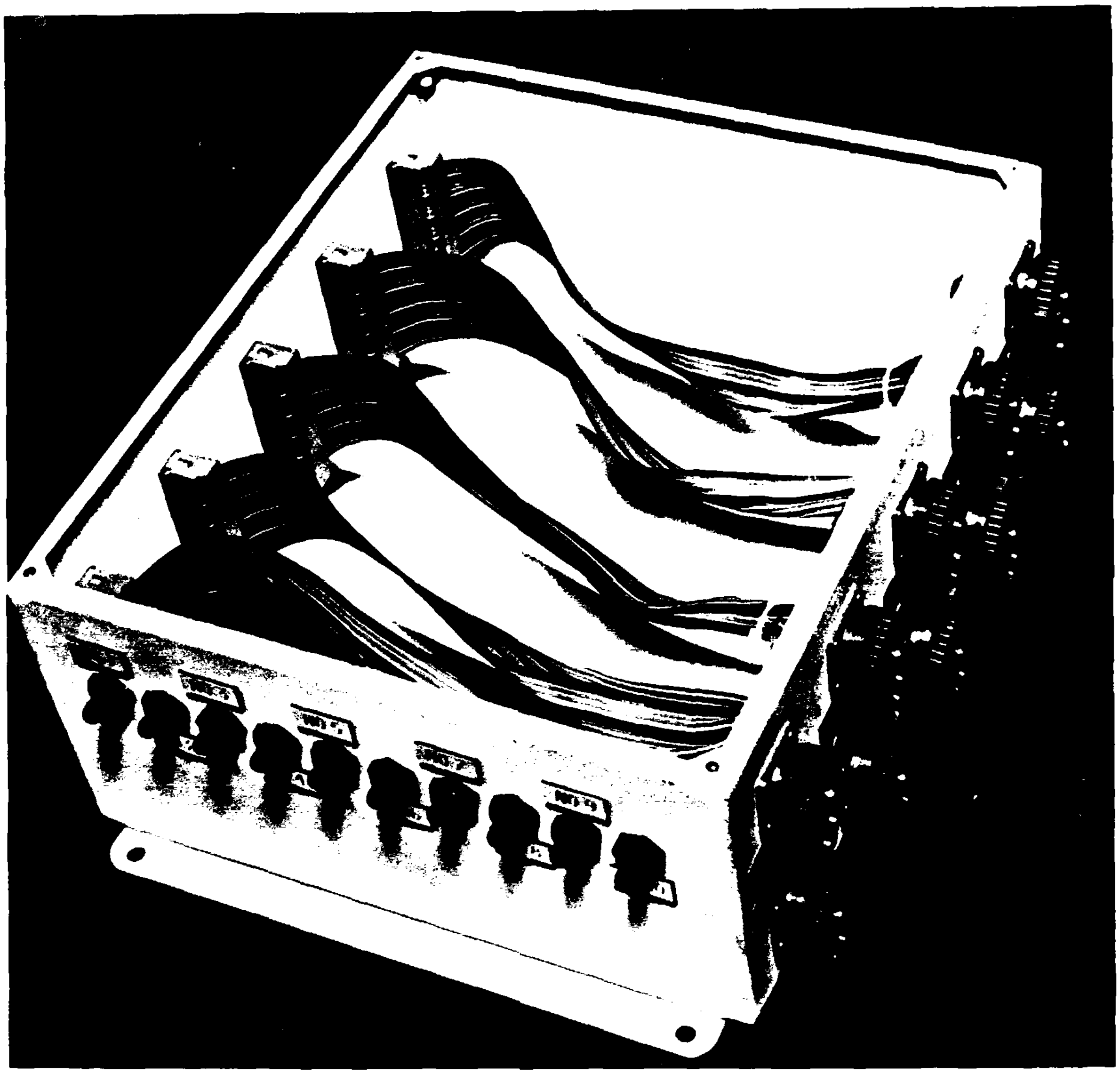


Figure B-3. Internal View of interconnect box.

g. Input the total number of mines being monitored by entering the command T M and pressing the RETURN key. A prompt will come up, asking you to enter the total number of mines. Enter the total as a three digit number (example, 3 would be 003).

h. Initiate the mine checking program by entering the command M C and pressing the RETURN key. The M C ON prompt will appear. A task is now running that continuously monitors the remote boxes.

-Monitoring Mines

a. When a mine detonates, the MDDS will automatically print the mine number, month, date, and time of detonation.

b. Periodically make sure that the VPR power supply, and the Transterm terminal are ON.

-Displaying the Mine Status.

There are five formats that can be used to display the status of mines. Entering the command M D and pressing RETURN causes a prompt to be displayed that asks you to make a display format choice. The following is a list of the commands and what they do:

Press 1 - Selecting this choice gives you a list of the detonated mines in order of mine number (1,2....total mines). Enter Q to quit.

Press 2 - This choice gives you a list of detonated mines in time order of detonation (from the first mine to detonate to the last). Enter Q to quit.

Press 3 - Gives you a list of detonated mines that are within a range of mine numbers. You enter the range when the terminal prompts you to enter the start and stop number. Enter Q to quit.

Press 4 - Gives you a choice of listing the status of all the mines or an individual mine. If a mine has not detonated, then the month, date, and time will be represented by zeros. Enter Q Q Q to quit.

Press 5 - This choice causes the VPR to count the number of detonated mines and print the total number.

Command Summary

a. Mine initiate - Entering M I RETURN causes all of the mine detonation times to be reset to zero. Remember to reset the hardware latches.

b. Mine reset - Entering M R *# # # RETURN causes mine detonation time of the mine you specify, to be reset to zero. Remember to reset the hardware latch.

c. Total count - Entering T C RETURN gives you the total number of mines being monitored.

d. Total mines - Entering T M RETURN allows you to enter the total number of mines that you will be monitoring. Enter the number as three digits (example 12 is represented as 012) and then press return(# # # RETURN).

e. Mine count program *ON* - Entering *M C RETURN starts the mine checking* program. A prompt comes up on the display to let you know that the mines are being monitored (MC ON).

f. Mine count program *OFF* - Entering M O RETURN terminates the mine checking program and returns the VPR: prompt.

g. Mine display - Entering M D RETURN causes a menu to be displayed. The menu gives you a choice of five ways to display mine detonations:

* # Denotes any number.

1 - Ordered by mine number. Press Q to quit.

2 - Ordered by time. Press Q to quit.

3 - Asks you for a range of mine numbers and then prints the detonated mines within that range. Press Q to quit.

4 - Individually or all (including nondetonated mines).

5 - A total count of detonated mines.

APPENDIX C - MDDS CHANNEL INTERCONNECTION DIAGRAM

- The purpose of this diagram (fig. C-1 and 2) is to make is easy to trace channels throughout the MDDS. Knowing where to access a channel at any point within the MDDS should aid in isolating problem areas.

- This diagram is most convenient to use if you have a channel number in mind and want to know how to access it at some point within the MDDS. If you have an inquiry of another type, refer to the body of this report.

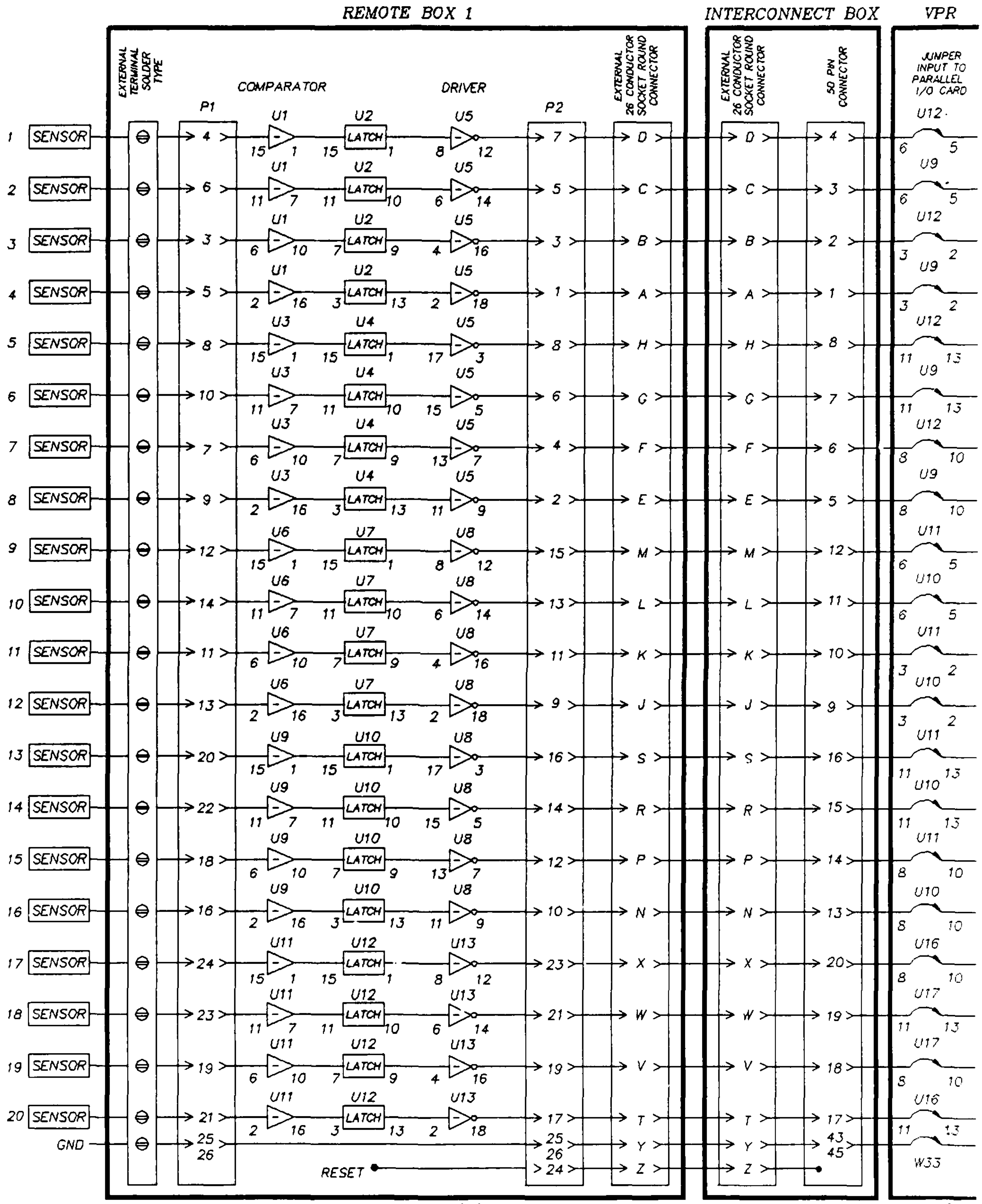


Figure C-1. MDDS channel interconnection diagram.

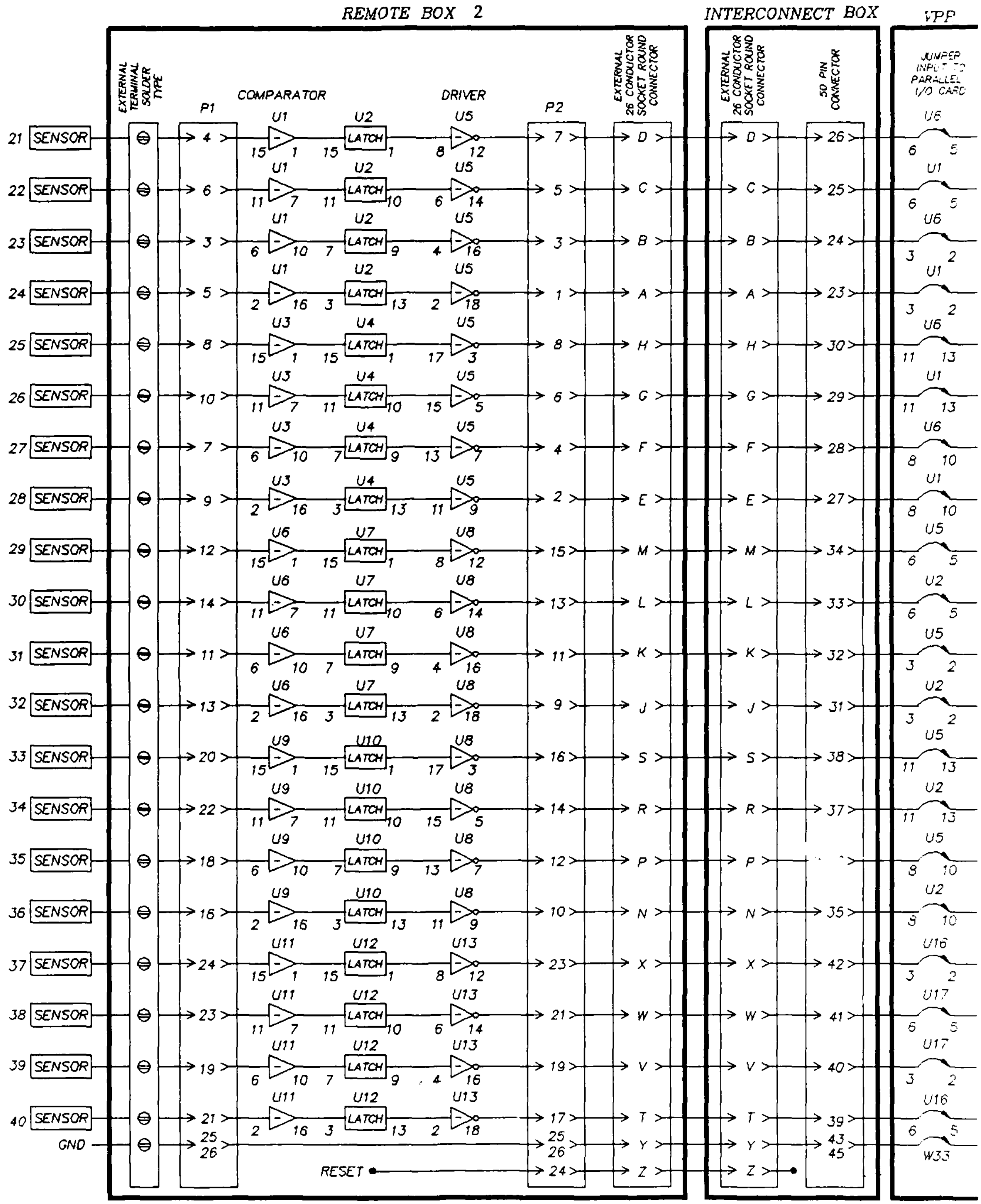


Figure C-2. MDDS channel interconnection diagram.

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APPENDIX E - ABBREVIATIONS

APG	=	Aberdeen Proving Ground
AP	=	antipersonnel
AT	=	antitank
CPU	=	central processing unit
DT	=	Developmental Test
g	=	acceleration due to gravity
IC	=	integrated circuit
LCD	=	liquid crystal diode
MDDS	=	Mine Detonation Detection System
mV	=	millivolt
TL	=	tripline
PROM	=	programmable read only memory
SD	=	self-destruct
RAM	=	random access memory
VPR	=	vehicle performance recorder
V	=	volts
VAC	=	volts alternating current
VDC	=	volts direct current
VRTX	=	versatile real time executive
Volcano	=	Multiple Delivery Mine System

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